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An interactive decision support system for technology transfer pertaining to organization and management

Roland, Ronald Jay

Monterey, California. Naval Postgraduate School

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NAVAL POSTGRADUATE SCHOOL

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AN INTERACTIVE DECISION SUPPORT SYSTEM

FOR TECHNOLOGY TRANSFER

PERTAINING TO ORGANIZATION AND MANAGEMENT

Ronald J. Roland

July 1980

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Rear Admiral J. J. Ekelund, USN
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Many conceptual organization models and DSS schemes have been developed. Operationalizing these concepts has not been accomplished due to the lack of an adequate tool or device to manipulate such complexity. DECAIDS is intended to demonstrate the feasibility of applying modern heuristic methods to effectively and dynamically model organizational interactions. It represents an important first step toward (1) providing a methodology for operationalizing complex management decision models and (2) enhancing the process of technology transfer from the designers and builders of the models to the decision makers.

AN INTERACTIVE DECISION SUPPORT SYSTEM
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PERTAINING TO ORGANIZATION AND MANAGEMENT

Ronald J. Roland, Ph.D.*

* Electronic Data Systems Corp
2150 Garden Road
Monterey, CA 93940
(408) 646-0465/1010

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R. J. ROLAND

CHAPTER I

INTRODUCTION

MIS Growth

"Spectacular growth in the use of computer-based information systems and quantitative approaches to managerial decision-making has created a need for both managers who can properly use sophisticated decision-aiding systems and for research towards understanding and designing such systems," (Kenreuther, 1978).

The application and use of automatic data processing (ADP) has become a standard, vital element for the efficient operation of most large, and many not-so-large organizations. Although the decision makers at the mid-and-top-management levels could equally benefit from the capabilities of ADP, the extent to which it has been applied beyond the operational management levels (accounting routines, operations control, production line robots, automatic guidance systems, record keeping, etc.) is minimal.

For example, the ADP support for the Department of Defense's World Wide Military Command and Control (WWMCC) System consists of a multimillion dollar computer network which provides a high degree of administrative reporting. Data from these reports are manually massaged to provide high level management the information needed for decision making. Another multi-million dollar system is the Navy's Tactical

Data System (NTDS), an automated, near real-time combat direction system for clearly defined combat operational roles. NTDS is a standardized set of pre-programmed instructions designed for highly structured, pre-determined situations. The flexibility needed to use this system for top level decision making or planning is not available. These systems reflect the typical use of computerized technology in public applications and are not atypical for the private sector. They provide massive support for the transaction processing and operational control functions, and very little support for higher management.

Zani (1970:99) trichotomized corporate decision making into strategic planning, management control and operational control. Figure I-1 classifies examples of activities in each of these decision processes.

Strategic Planning	Management Control	Operational Control
Choosing company objectives	Formulating budgets	
Planning the organization	Planning staff levels	Controlling hiring
Setting personnel policies	Planning working capital	Controlling credit extension
Setting marketing policies	Formulating advertising programs	Controlling placement of advertisement
Setting research policies	Selecting research projects	
Choosing new product lines	Choosing product improvements	
Acquiring new divisions	Deciding on plant rearrangement	Scheduling production
Deciding on nonroutine capital expenditures	Deciding on routine capital expenditures	
	Formulating decision rules for operational control	Controlling inventory
	Measuring, appraising and improving management performance	Measuring, appraising, and improving workers' efficiency

Figure I-1. Examples of Activities in Decision Processes. (Zani, 1970:99)

Furthermore, Zani (1970:96) suggests the major determinants of information system design are:

opportunities and risks,

corporate strategy,

company structure,

management and decision-making processes,

available technology, and

available information sources.

These determinants according to Zani (1970:99), are the factors "that should structure the characteristics of information provided to management, and therefore the design of the system itself." However, until the recent advances in computer hardware, software, and communications technologies, inclusion of these determinants in most information systems was impractical. It has been difficult to build systems that could effectively accommodate the unstructuredness of the strategic planning and management control decision making activities (Keen and Scott Morton, 1971:59). The characteristics of operational control data include being largely internal, well defined, detailed, highly current, accurate and repetitive, and fit well into traditional ADP processes. The major design determinants that would provide more relevant information to the management control and strategic planning officials (opportunities, risks, etc.) have historically been relegated low organizational priority in MIS implementation.

The primary emphasis of most MISs is in support of the operational control activities, with reduced support for the less-structured (Keen and Scott Morton, 1971:62) management control level and very little, if any, support for strategic planning. Today's top level managers are faced with ever more difficult problems and operate within complex environments with limited resources. In order to make the most effective decisions, corporate officials, planners and managers must be provided the tools and technologies designed to satisfy their needs at the strategic planning and mid-management levels. Few, if any MISs have been implemented to satisfy these unique requirements.

Decision Aids

Top management can avail itself of many of the tools of computerization. There have been many efforts to describe how a management information system can be built to satisfy (in part) middle and top-level decision making requirements (Keen and Scott Morton, 1978:54-57; Lucas, 1978:332-338; Burch and Strator, 1974:68, 52-58). Advanced ADP techniques which could be used in direct support of higher management needs are in the field known as operational decision aids (ODAs) or decision support systems (DSSs).

The term operational decision aid (ODA) is defined within a specific, on-going, research program started in 1973 by the Navy's Office of Naval Research (ONR) to address

issues having to do with decisions made by relatively senior officers and their staffs, e.g. task force commanders. The program is aimed at automating certain elements of naval command and control systems. The major components of the Navy's ODA program are computer science, decision analysis, systems analysis and organizational psychology (Sinaiko, 1977:1).

Conversely, decision support system (DSS) is a title used extensively in the open literature. The DSS is computer based support for management decision makers who are dealing with semi-structured problems. The system is usually a collection of levels of support ranging from access of facts to the use of filters and pattern-recognition for information retrieval, simple computations, comparison, projections, etc. DSSs may include various models useful to managers (Keen and Scott Morton, 1978:97) and are generally, but not necessarily supported by a MIS.

Finally, a decision aid is considered a human-system interface designed for the specific purpose of supporting and enhancing the manager's or commander's decision making ability (Keen and Scott Morton, 1978:97). It is a tool which can be used by the decision maker to assist in or enhance effective decision making. Although a pen or pencil may be included in this definition the use herein will mean mechanical or electrical (usually computer assisted) devices.

A decision aid, for the purposes of this research, is any technique or procedure that helps to restructure the methods by which problems are recognized, understood and analyzed, and decisions are made. This process may, for example, involve the systemization of procedures that assign quantitative values to action alternatives and calculation of utilities for probable outcomes. A decision support system is a specific category of decision aid. In order to minimize confusion DSS will be used throughout the remainder of this study except where specifically discussing the Navy's ODA work.

DSS technologies have not proliferated for a variety of reasons, two of which are noteworthy. One is the inability to effect adequate transfer of technology from the research/academic areas to the manager. That is, managers do not understand many of the decision models that might be included in a DSS and therefore lack motivation to use such tools. The other, and perhaps more important reason, is the lack of a model to describe decision support tools based on given organization variables such as organization structure, managerial style, environment circumstances, organizational needs, and technology. That is, a model is needed to guide or direct the user toward appropriate models and techniques appropriate for the given situation.

Technology Transfer

Technology transfer is "the process whereby technical information originating in one institutional setting is adapted for use in another institutional setting," (Doctors, 1969:3). This transfer is a complex mechanism that involves the coordination of many facets of the techno-socio-politico-economic system.

Charles Kimball (1967:42) states that, "Technology transfer of any significance will only occur when the right people, the right markets, and the right ideas coincide with usable technology at the right point in time. The technological content, per se, may be the least important element in the transfer process."

Until only a few years ago, economists tended to overlook the importance of technology innovation and technology transfer. Most macroeconomic formulas explained economic expansion in terms of the quantitative growth of labor and capital. The "residual" of unexplained growth was labeled "technical progress" and left essentially at that.

In 1957 it was shown that more than half of the increase in American productivity had been due to scientific and engineering advances. As a result of Solow's pioneering efforts, economists today appreciate that the primary input to economic growth is the advancement and utilization of knowledge (U.S. Congress Report, 1975:1-2). This knowledge could not be utilized without technology transfer.

The major implication of this realization was that for a country like the United States a high priority must be given to innovation and in particular to the adoption of new technologies, and the effective transfer of the knowledge gained from these technologies. Therefore, the status of technology transfer should be of central concern to the research as well as management communities.

Innovation and technology transfer as a means of growth are now well recognized on the micro and macro levels for both the business firm and the nation. A primary reason that innovation and technology transfer are vehicles for growth on the macro level is that when investment in these areas is substantial and growing, economic expansion is likely to be interrupted. Bragaw (1970:8) shows that the "advance of knowledge" contributed about 40 percent of the total increase in national income per person employed during 1929-1957. Technological change and diffusion is a major factor for the economic strength of the United States. The rise in the knowledge industry has affected the nature of work and the allocation of resources within this society.

The importance of and need for transfer of technology from the research to management was underscored by Walsh (1979:27) in an interview with Dr. R.M. Davis, Deputy Undersecretary of Defense for Research and Engineering (Research and Advanced Technology). Dr. Davis emphasizes the formation of high level government groups which are assigned

specific responsibility for bringing together the research community with other science and technology personnel. This is a major step toward effecting an interchange of needs, concepts, and capabilities.

As originally conceived by Doctors (1969:3) technology transfer is the process whereby scientific or technical knowledge is transferred from one area of use or development to another. However, current thought takes a broader perspective. According to Creighton, Jolly and Denning (1972:18), "The result of technology transfer may thus be acceptance by a user of a practice common elsewhere, or it may be a different application of a given technique designed originally for another use." In either context, however, an important element in the process is the active efforts of one or more individuals in affecting the transfer activity. A name generated by Essoglou (1975:6) to describe the function of these individuals is "linker". Essentially, it is through the innovative and persistent efforts of these linkers within an organization that the technology transfer process is achieved. Were it not for their efforts, the process would probably still occur, but at a pace more akin to diffusion.

The model developed by Creighton, Jolly, and Denning (1972:18) of the information linker is depicted in Figure I-2. Within this model of technology transfer (Figure I-2) the supplier may be considered the researcher and the user equated to manager. A linker is perceived as the primary

informal factor to effect the technology transfer. Certain other formal as well as informal factors are represented.

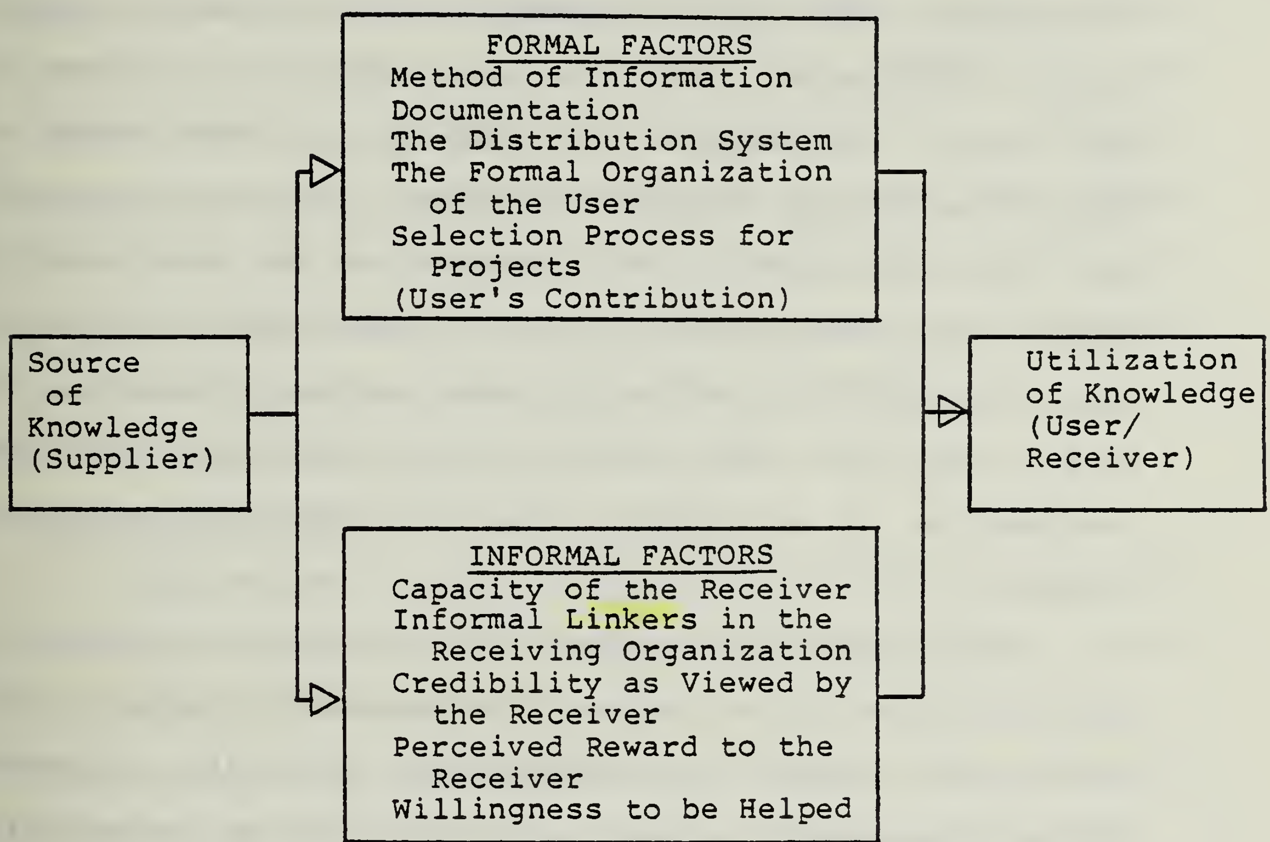

Figure I-2. The Information Linker Model

(Creighton, Jolly and Denning, 1972, p.18)

There are some inadequacies in this model. Feedback from the user to the supplier is absent although it is critical to identify user requirements prior to satisfying them. Another assumption is that the "linker" will be available and able to communicate not only user needs but supplier capabilities. In view of the nomadic personnel movement experienced by many firms this may be a costly and erroneous assumption.

A major problem for many of today's organizations and hence managers, is the lack of knowledge concerning available technologies that could be applied toward increasing company profits and growth. To a much less degree the converse is also true. Researchers, in general, are not aware of specific management dilemmas and needs. Any tool and tools that could alleviate this communication and understanding barrier will enhance the transfer of technological skills and applications to the user would prove extremely valuable. If such a tool could additionally provide researchers with some perspective of management needs it would be even more valuable.

"Many important elements of the manager's planning functions are still not well supported by computerized information sytems," (Cleland and King, 1975:146). Computer science, management science, and communications technologies are now capable of providing higher management level support, but the problems of educating the user in current capabilities and of describing a model to meet specific decision-maker requirements have not been solved. Education of the technologists has similarly been ignored with respect to their learning the user requirements, needs and capabilities (or lack thereof).

A possible solution to both of these problems is the development and implementation of a model which would describe relevant organization characteristics in a manager's

language, and prescribe capabilities of appropriate decision support systems in simple technological terms. A graphical model or decision table representation might support such an effort if the number of variables and capabilities were small; however, modeling even a minor part of a manager's decision making situation can quickly become a very complex task. If current technological capabilities of DSSs are added to the model it is evident that an automated manipulation and analysis capability is needed.

Purpose of Study

The purpose of this study is to develop a testable, prototype computer model which may be used to effect technology transfer pertaining to decision making in organization and management. The model will prescribe capabilities of relevant decision support systems based on the characteristics of certain organizational variables, such as available technology, managerial style, environment of the user, and timeliness, or task requirements of the decision environment. Essentially this paradigm will include both the micro and macro perspective described by Franz (1978:301).

The model will be designed for managers to use in identifying decision aiding capabilities which could support their decision making requirements. Concurrently this design can be extended for use by DSS researchers to identify

managers' needs in order to better direct research and design efforts.

Since the model is a prototype, it is not intended for release to operating managers in supporting their decision making efforts. Rather the prototype is intended to demonstrate feasibility and to be built upon by other researchers and designers. Ultimately, it is hoped that a more complete computer model, based on these conceptual foundations, will be developed and implemented.

Developed as a prototype, this decision aiding system, called DECAIDS (Buscemi and Masica, 1979), is presented as a method of describing and studying the complex interactions of organizational variables. Resultant prescriptions presented by the DECAIDS model will consist primarily of a group of capabilities which should be considered for inclusion in future DSSs planned in support of a given organizational setting. Conversely, given specific DSS capabilities the DECAIDS should describe an organizational setting to maximize the effectiveness of using the DSS. As the organization changes or new DSS capabilities are introduced the model can be continually updated.

Context of the Research

The context of the research includes the related disciplines of organizational theory and behavior, computer science, decision science and artificial intelligence. The

major, abstract concepts include decision support systems (DSSs), decision analysis, contingency matrix, and production systems. Each of these concepts is introduced here and more thoroughly reviewed in later sections.

DSSs have been introduced as tools or applications designed and implemented to support specific managerial circumstances. Decision analysis is a quantitative methodology which permits the systematic evaluation of the costs or benefits accruing from a course of action that might be taken in a decision situation. It includes identification of alternative choices, the assignment of values for outcomes and expression of probability of these outcomes being realized (Barclay et al., 1977:vi). Decision analysis techniques such as multi-attribute theory, prioritization schemes, and decision structuring, for example, have been used as a basis to build DSSs.

The concept of a contingency matrix is an approach to identify and develop functional relationships among organizational variables. Luthans and Stewart (1976:6) suggest a three dimensional contingency matrix (Figure I-3) to describe various organizational interactions. By drawing on the combined research of several authors, (Katz and Kahn, 1966; Thompson, 1967; Churchman, 1968; Shetty and Carlisle, 1972:38-45; Lorsch and Morse, 1974; Kast and Rosenzweig, 1974), they define an organization as a social system consisting of subsystems of resource (or energy) variables in

an environmental suprasystem working together to achieve some set of objectives. Subsequently Luthans and Stewart (1976:17) identify contingent relationships and locate them within the matrix. Operationalizing the matrix, however, is a practical impossibility when studying any medium to large organization because of the complexity of the various interactions.

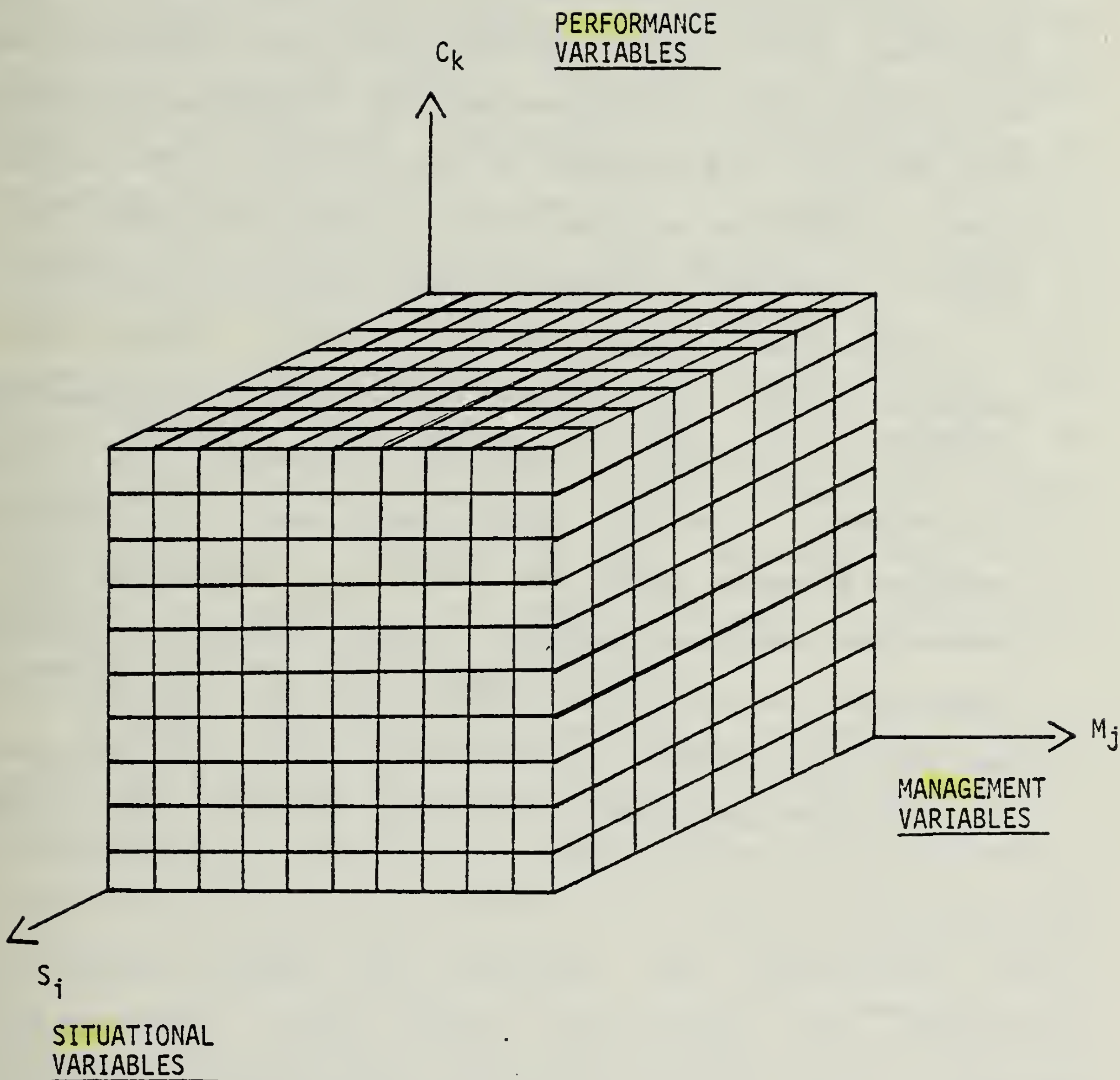

Figure I-3

A GENERAL CONTINGENCY MATRIX FOR MANAGEMENT

(Luthans and Stewart, 1978)

Production systems[1] originated from early work in symbolic logic by Post (1943:197-268). A production system is a collection of rules of the form CONDITIONS --> ACTIONS (Waterman, 1976:1) where the CONDITIONS are statements about the contents of a data base and the ACTIONS are procedures that may alter the contents of the data base. The system is given a condition to make true, a premise to prove, or, in effect, a question to answer through deductive inference.

Production systems provide a simple, uniform way of handling control flow and data management in programs which exhibit intelligent behavior (Newell and Simon, 1972:04-806). They are particularly useful for developing computer programs which can learn from experience, and can demonstrate adaptive behavior. Such programs are generally categorized as artificial intelligence (AI) systems. AI is particularly amenable to processing conditions that can be stated in the CONDITIONS --> ACTIONS (or IF --> THEN) format.

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[1]Riggs (1950:5) described typical production systems as consisting of an input, a conversion process, and an output. As used in this research the inputs are data, the interpretation of the data is the conversion process, and intelligence is the output or product. More specifically these production systems used in artificial intelligence applications are sets of rules which form premise-conclusion or situation-action pairs and are combined in such a way as to produce information (Winston, 1977:144).

Propositions

The major thrust of this study is to determine if the capabilities of decision support systems can be predicted by describing the organizational framework within which the DSSs exist or are planned. Conversely, can characteristics of organizational variables be described in a manner that will enhance the success of specific DSS designs? In order to study these propositions it is necessary to identify capabilities which describe decision support systems and select specific organization variables which represent an organization-decision support system framework. Once identified these capabilities and variables may be so arranged or modeled as to suggest success or failure of proposed DSS-organization combinations.

A model depicting organizational situations can be useful for understanding decision support system capabilities appropriate to assist the organization decision maker. Complexity of the initial model can be reduced by considering a limited number of variables and determining their interaction. Once these interactions are understood additional variables and their interactions can be introduced and studied. This research emphasizes the initial implementation of these variables: Group, Environment, Task, Structure, Individual and Technology. They will subsequently be referred to as the GETSIT variables.

Operationalizing initial interactions of the DSS and the original variable characteristics would be possible, albeit time consuming, by manual means. However, as the knowledge base is enriched with additional characteristics and interactions, a computer model will be required to effectively evaluate the data. The availability of an interactive computer model for management interaction (retrieval and update) is appropriate and desirable.

This research provides the basis for identifying the necessary components to design and build automated decision aids in support of specific managerial requirements. The thrust of this study, operationalizing a prototype computer model to enhance effective DSS design and implementation, also provides insight for future research. Finally intra-organization attributes, their interactions and descriptions, both general and specific, and what constitutes the field of DSS are documented.

In a more formalized sense the propositions may be stated as:

1. If appropriate organization variables are identified and manipulated, one result will be to suggest corresponding changes in that organization's decision support system capabilities.

2. If the decision support system capabilities change then corresponding organization changes may be required in order to effectively utilize the DSS in question or under investigation.
3. The GETSIT variables are sufficient to describe the organization.
4. An AI technique is suitable for operationalizing the concepts from propositions 1, 2 and 3.

The developmental approach to identifying various DSS/organizational-process contingencies and creating a computer model to reflect that interaction is a valid methodology. Continued expansion of such a model could result in the capability to investigate an increased number of contingencies. The following six examples are provided as suggested contingent relationships that may be either studied through such a model or, in fact, included as a part of the model's knowledge base.

1. If the organizational task is composed of well structured problems then there will be minimal need for a DSS. Conversely, if the task involves a high degree of ill structured problems several DSSs may be identified.
2. If the individual (leader) is not skilled in technical analysis then DSS support will be delegated further down in the organization than otherwise.

3. If the individual (leader) is knowledgeable in technical and decision analysis methods then a higher degree of DSS support will be identified than otherwise.
4. If the organization structure is either pyramidal or divisional in nature then analytic decision aids are appropriate.
5. If the structure is pyramidal then real-time decision aids will be most appropriate.
6. If large screen displays are identified then the structure is most likely pyramidal.

Methodology

Developmental research in a subject area which attempts to integrate various disciplines requires data from multiple sources. The methodology used in this research includes a systematic review of the literature concerning each GETSIT variable and decision support system capabilities. This literature review of organizational processes will be accomplished in order to substantiate the relevancy of these variables and capabilities to this study. This review will also serve the purpose of identifying contingent relationships, stated in IF CONDITION-->THEN ACTION (production rule) formats, among the variables and capabilities and as associated with information processing technologies.

In addition to the literature review, interviews with corporate managers will be conducted. The purpose of the interviews is two fold. First they will provide a means of validating the use of the GETSIT variables by identifying their use within a wide variety of organizations. The interviews should also provide additional contingent relationships concerning variable and DSS interactions. Finally, the interviews will represent the first expert knowledge used in the DECAIDS knowledge base.

Data collected through the interviews will be used to support selection of the GETSIT variables and to suggest various DSS and GETSIT relationships. Only basic descriptive statistics, the mean, mode and median, will be used in data analysis for several reasons. First, the data will consist of highly qualitative, subjective estimates over a range of six variables (the GETSIT variables) and a multitude of DSS capabilities. Second, the sample size will be relatively limited and will preclude developing any reasonable degree of statistical confidence measures through procedures such as multiple regression analysis. Finally, the modeling techniques of artificial intelligence support the inclusion of certainty factors within the knowledge base providing a high degree of complex classification which is analogous to discriminant analysis.

A second literature review is necessary to determine the historical nature and use of artificial intelligence systems

for modeling the organization process. Having accomplished this review suitable resources (hardware and software) must be located to design, build and implement a model such as DECAIDS. Currently, such resources are known to exist at Stanford University, Carnegie-Mellon University, University of Southern California and the Rand Corporation.

The effort to locate the required computer resources and develop a prototype model will be done in parallel with the literature review. As such not all of the production rules that result from the review will be incorporated in the initial model, however procedures to both manipulate DECAIDS and enlarge its knowledge base will be provided.

The next chapter (Chapter II) will discuss the development of a model capable of storing and manipulating a large number of complex contingent relationships. It will provide an introduction to artificial intelligence techniques and indicate how they may be used to examine human decision making.

Chapter III will provide background for this study. It will discuss the concept of decision support systems, define artificial intelligence and provide examples of its use in support of various managerial decision tasks.

CHAPTER II

MODEL DEVELOPMENT

Introduction

Over 100 GETSIT-DSS contingent IF CONDITION-->THEN ACTION combinations are formed in Chapters IV and V. These combinations include one or more characteristics of six organizational GETSIT variables and various decision support system capabilities. Conventional organization process models are extremely limited in their ability to efficiently or effectively study the complex interactions of this number of variables. The use of a contingency matrix or applied artificial intelligence are two possible means of providing a usable model.

Contingency Matrix

Figure II-1 illustrates a continuum perspective of how various GETSIT-DSS relationships might be conceptualized. The six horizontal lines represent continuums of the organization variables ranging between limits of specific variable characteristics. The outer left and right columns illustrate possible decision support system capabilities that could support the organization variable along the continuum. Certainty factors, assigned probability functions, can be used to quantify the certainty of given organization-DSS combinations, however, the interaction even at this simple

ORGANIZATION VARIABLES

DSS Capability

- Large Scale Computer
- Regular reporting
- Little need for real time
- No time-share
- Batch orientation
- Closed ADP organization
- Single Large DB
- Centralized
- Single language

	Variable	
STRONG LARGE STABLE OLD	GROUP	NEW WEAK SMALL CHANGING UNSTABLE
STABLE PREDICTABLE	ENVIRONMENT	UNSTABLE DYNAMIC CHANGING UNSTRUCTURED
WELL DEFINED PROGRAMABLE SIMPLE REPETITIVE	TASK	ILL DEFINED VARYING
LINE	STRUCTURE	MATRIX PROJECT
DICTATOR AUTHORITARIAN INDIVIDUALISTIC LONER	INDIVIDUAL	DEMOCRATIC WEAK
LOW SINGLE TECHNOLOGY i.e. 360/67	TECHNOLOGY	HIGH MULTIPLE TECHNIQUES FRONT LINE

DSS Capability

- Multiple types of displays
- Individual or personal terminals
- Multiple sensor data collection systems
- "What if" questions
- Multiple data bases
- Decentraliz
- Open ADP organizatio

Figure II-1. GETSIT-DSS Continuum.

level of detail becomes very complex when the number of possible combinations is considered.

Figure II-2 shows a small number of suggested GETSIT characteristics, for Group, Structure and Technology. Taking the variable Structure from Figure II-1 to illustrate system complexity, a two dimensional contingency matrix is presented as Figure II-2. While still incomplete, the magnitude of possible interactions is apparent. Expansion of this matrix to include the other five variables and all their interactions becomes a practical impossibility to manaually or conceptually manipulate in the 2-dimensions of Figure II-2.

A different two-dimensional contingency matrix, Figure II-3, is described by Luthans (1976:47-49) as a conceptual framework for contingency management. Cascading matrices (Luthans 1976:49) are suggested as a solution to numerous iterations of relationships between relevant environment and management variables. No limit to the number of matrices is suggested. In addition no methodology is provided to correlate variable interactivity or coordinate the levels of matrices.

Luthans and Stewart (1976:6) extend the two-dimension contingency matrix to three dimensions as discussed in Chapter I (Figure I-3). This 3-d form uses management, performance and situational variables to describe organizational activity. As in the original concept (Figure

ORG. VARIABLE	VARIABLE CHARACTERISTIC	DSS CHARACTERISTICS REAL TIME	TIME SHARE	AUTO MSG	GRAPHICS DISPLAY	ALPHA DISPLAY	AUDIO ALARM	LARGE SCALE DISPLAY
GROUP	FORMAL:							X
STRUCTURE	FORMAL:							
	LINE					X	X	
	STAFF				X			X
	FUNCTIONAL							
	MATRIX			X				
	UNK							
	INFORMAL:							
	CENTRALIZED							
	CONSULTATIVE		X					
	TRANSACTIONAL							
	DELEGATED							
	DECENTRALIZED							
	UNK							
TECHNOLOGY	HIGH							

Figure II-2. GETSIT-DSS Contingency Matrix For Structure.

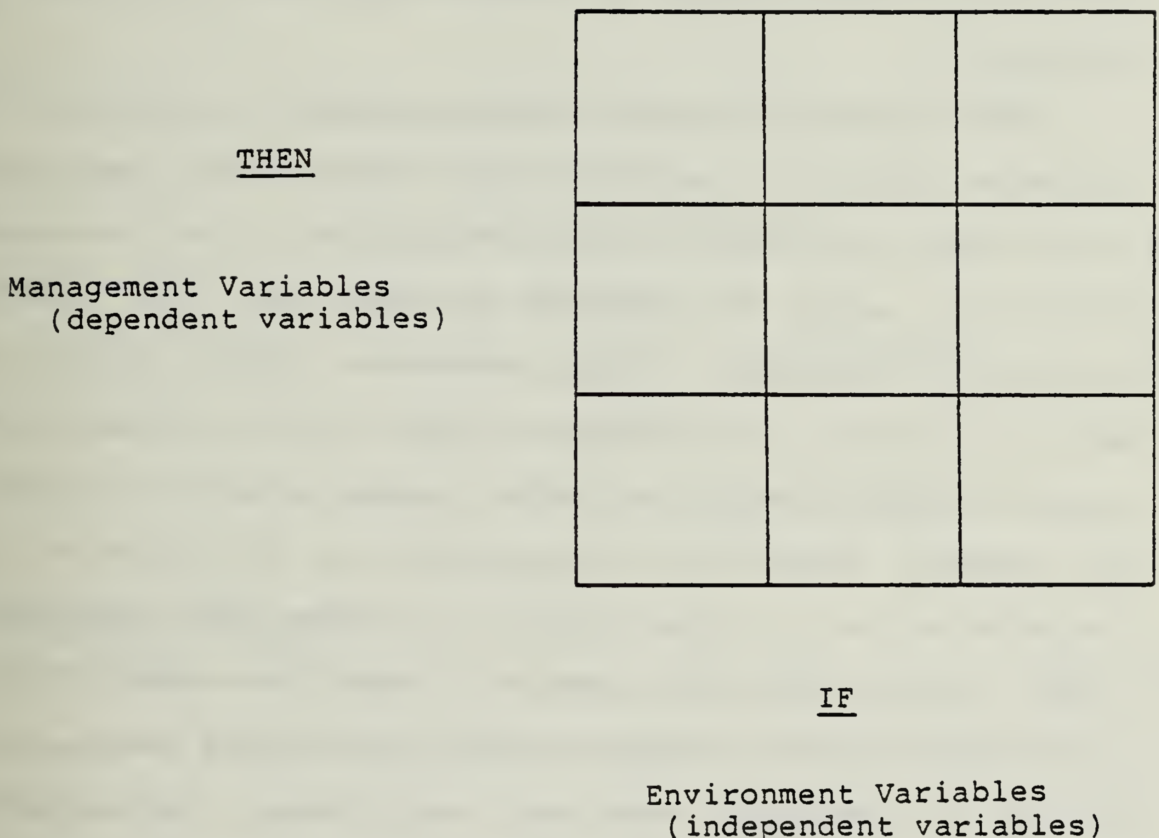

Figure II-3. The Conceptual Framework For Contingency Management.

(Luthans, 1976:48)

II-2) the number of possible interactions is such that manual data manipulation becomes more and more difficult as the number of relationships grows. Manually extending the contingency matrix concept to greater than three variables is difficult.

The concept of the contingency matrix is sufficient to introduce GETSIT-DSS relationships; however, the complexity of the organization-DSS interactivity is such that automated support is needed to implement a model that will reflect real-world situations. Such automation should ideally be able to take the IF CONDITION-->THEN ACTION statements and produce logical conclusions to any number of such statements. For example, Figure II-4 illustrates how to structure the characteristics of organizational varibles into production rules. These production system (IF CONDITION-->THEN ACTION) rules then define a subset of DSS capabilities which would satisfy the originally described interactions. Each of the 6 GETSIT variables will be assigned characteristics derived from the research. These sets of characteristics may or may not be independent. In addition, the characteristics themselves may be modified by the model user at any time. A specific example of this as visualized is provided in Figure II-5.

IF environment is dynamic,
AND TASK is low cost,
AND TASK is high priority,
AND STRUCTURE is consultative,

THEN suggested DSS capabilities include
individual displays,
automated message handling,
real time support, and
consulting service is recommended.

Figure II-4 Production Rule Example.

Production Systems

Production system is the name given to a class of computer programs which embody special constraints with regard to control flow and data management. The basic simplifying constraint is that all program statements are of the form "IF CONDITION-->THEN ACTION," i.e. IF the CONDITION is true THEN perform ACTION. The constraints lead to system characteristics that facilitate writing computer programs which exhibit intelligent behavior. The term "production" stems from its use by Post (1943:197-268) in his

VARIABLE	GENERAL CHARACTERISTICS	SPECIFIC (EXAMPLES)
Group	G_j, j = 1 to g	G_1 = Formal
Environment	E_j j = 1 to e	E_1 = Turbulant
Task	TA_j j = 1 to ta	TA_1 = Semi-structured
Structure	S_j, j = 1 to s	S_1 = Centralized
Individual	I_j, j = 1 to i	I_1 = Skilled
Technology	TE_j, j = 1 to te	TE_1 = High
DSS	DSS_j, j = 1 to n	DSS_1 = Real-Time
		DSS_2 = Time share
		DSS_3 = Graphics display
		DSS_4 = Not needed
		DSS_5 = Tutorial
		DSS_6 = Individual display
		⋮

Possible Production Rules:

1. IF G_2, G_3, TA_{12}, S_1, I_{22} AND TE_9
   THEN DSS_2, DSS_6, DSS_{219} AND DSS_{300}.
2. IF E_2, TA_3 AND S_4
   THEN DSS_1 AND DSS_{100}.
3. IF DSS_1, DSS_2, DSS_3, DSS_4 AND DSS_{31}
   THEN G_3, E_4, TA_5, S_6 AND TE_{93}.

Figure II-5 Production System Model.

symbol manipulation systems. These were systems composed of grammer-like rules for specifying string replacement operations. A typical rule in such a system might have the form AYB→AZB, meaning that any occurrence of the string Y in the context of A and B would be replaced by the string Z.

A production system is a collection of rules of the form CONDITIONS-->ACTIONS (Newell and Simon, 1972:33-34, 804-806), where the conditions are statements about the contents of a global data base, and the actions are procedures which may modify the contents of that data base. The conditions and actions are not restricted to string matching and replacement; a condition can be any expression which has a truth value that can be determined from the data base, and an action can include any operation which modifies the data base. When the conditions of a production rule are true the rule can "fire," which means that the actions associated with the true conditions are executed. The activity involved in firing a rule--determining which rules have true conditions, selecting one of them, and executing its actions--is considered one cycle through the system, and can be characterized as a CONDITION-->ACTION cycle. A production system cycles continuously, halting when the conditions for all production rules are false or a special halting action is executed. Thus production rules fire in a data-dependent fashion, operating quite differently from typical computer

programs which have sequential control or explicit knowledge about where code will next be executed in the program.

Applications of Production System Technology

Production system architectures have been used in a number of different systems. An interesting example of a condition-driven architecture is the Meta-DENDRAL system (Buchanan et al., 1972). Meta-DENDRAL is a program designed to formulate rules of mass spectrometry which can be used by Heuristic DENDRAL, a performance program developed for the analysis of molecular structures. The rules learned by Meta-DENDRAL are represented as production rules of the form SITUATION --> PROCESS, where each situation is a description of a subgraph which represents some class of molecular structures, and each process is an action that will change those structures, such as breaking a bond or moving an atom. Condition testing is based on pattern matching, and all rules with true conditions are executed in some arbitrary order.

MYCIN is an example of an action-driven production system architecture (Shortliffe et al., 1972:303-320). The MYCIN program is a production system designed to interact with a physician and advise him regarding antimicrobial therapy selection. The system uses over 200 decision rules to guide its action-directed search for a diagnosis. It not only uses the data base and the rules to validate rule conditions, but also queries the user of the system (the

physician in this instance) when the information is not in the data base and cannot be deduced from the rules. Thus the user is able to provide the system with current information being diagnosed.

A system which uses both condition-driven and action-driven rules is RITA (Anderson and Gillogly, 1976). The RITA system is designed for writing computer programs called agents which intelligently interface the user to the outside computer world. RITA's production system control structure provides the degree of simplicity and modularity needed to make program organization straightforward and program modification relatively easy. The system is human engineered, i.e., the programs or RITA agents have an English-like syntax which makes them easy to write and almost self-documenting. The language primitives in RITA permit the user to interact with other computer systems, even to the extent of initiating and monitoring several jobs in parallel on external systems.

Production systems are an interesting form of computer program organization for a number of reasons. First, they provide a parsimonious way of modeling human cognition, i.e., the production system data base can be compared to human short term memory, and the production rules to human long term memory. Second, production rules tend to represent independent components of behavior and thus the creation and addition of new proodduction rules can be incremental, a

feature which facilitates modeling learning processess (Waterman, 1970:121-170, 1975:296-303). Third, when a large body of knowledge is represented in rule form, as in MYCIN, it becomes easier to explain, justify, and analyze the rationale used by the program to reach its decisions. Finally, the simplicity of the RECOGNIZE --> ACT, or CONDITION --> ACTION control structures (no branching or block structure) facilitate automatic program creation, debugging and verification.

Extension of the Contingency Matrix

The contingency matrix in Figure II-3 may be an appropriate model to extend conceptualizations about organization interactivity. It may also be operationalized and manipulated if the number of production rules (IF- THEN relationships) remain low and simple. Increasing the number of variables and raising the complexity and number of production rules as illustrated in Figure II-4 requires another approach to modeling. One method to extend the matrix to n-dimensions is to either adopt or create a production system.

Two such systems RITA and EMYCIN (an extension of MYCIN) were available to the author although neither had ever been used to model management decision making behavior. EMYCIN was selected for the prototype system because of the availability of hardware support, the inclusion of certainty

factors and its control structures. As an extension of MYCIN the facilities of EMYCIN were available to be used in creating the prototype system called DECAIDS.

Specific to EMYCIN and DECAIDS

Production rule systems provide a method for encoding "expert" knowledge about some field, or domain, of information and offer techniques for searching this knowledge base to provide answers to questions in the domain. As with conventional computer programs, artificial intelligence (AI) programs are characterized by having a data base, which is operated on by some pre-determined control strategy. An AI program is more specifically seen to have a global data base, a production system of rules to accomplish operations, and a control strategy to determine which rules to apply and in what order (Nilsson, 1978:1-45).

The DECAIDS system is the set of rules which operates within the EMYCIN production system architecture. Each of these rules has one or more premises to be verified. Upon verification of these preconditions or premise clauses, the rule's conclusion is executed. Information in the DECAIDS knowledge base may be modified, deleted, or added by the action of a rule (Waterman, 1976:3)

In affecting parameter values, rules are considered to be modularized pieces of coding and distinct pieces of information. Each is a separate "chunk" of knowledge used in

the program (Davis, 1977:7). In performing operations on a knowledge base, rules are controlled by a rule monitor and a rule interpreter. A rule monitor is a computer software subroutine designed to effect the desired control strategy while a rule interpreter is a subroutine called by the monitor to execute rules, and, thereby, determine the values of parameters.

When individual rules modify the knowledge base, no extensive changes to program code are necessary because each rule is modularized. However, it must be noted that while the rules and parameters may be added or deleted without requiring any changes in the knowledge base, their additions or deletions may affect the logic required to present a complete path of question-asking reasoning to a root node. Due care must be exercised not to disturb the backward-chaining path used to reach a logical conclusion.

In using a production system to address a problem, problem states, the rules, and termination conditions must be considered. Problem states are the total number of alternative solutions possible to achieve a goal. This is also referred to as the problem space. These alternative solutions must be formulated into some standard computer programming data structure for program use. List structures have been used by artificial intelligence programmers as the most appropriate data structure. LISP and INTERLISP are

currently the most often used computer languages for AI applications.

State descriptions describe rule preconditions. The approach to a problem in an AI program is through a sequence of state descriptions and rule applications which modify a knowledge base to arrive at some termination condition. The rule monitor is responsible for recognizing the termination state or condition as specified by the system designer.

The control strategy has the responsibilities of selecting rules, accounting for problem states (parameter values), and accounting for rule usage. There are two basic control strategies: irrevocable and tentative. The irrevocable method applies a rule with no reconsideration of its effect on a knowledge base. An example of a tentative system is the backward-chaining used in DECAIDS. Reconsideration of a rule's effect is seen as the continual computation of certainty factors along a traversal of the AND/OR tree, described later in this section. Control strategies may further be explained by describing the two general types of production systems, condition-driven and action-driven (Nilsson, 1978:1-22)

The method of interaction with the knowledge base is the deciding factor between the two systems. In a condition-driven system, the conditions of the premises are compared to the data base and the rules whose conditions match the data base are chosen to have their Right-Hand-Side

(RHS) executed. The action-driven system interacts with the knowledge base by first checking the RHS's This procedure parallels a logical implication with its "1 and 2 imply 3" statements. The system attempts to prove that 3 is true by checking for 3 in the data base and, if this is false, then proving that 1 and 2 are true -- therefore 3 is true -- and adding 3 to the data base (Waterman, 1976:3).

A conflict set, in a condition-driven system, is the collection of all rules whose Left-Hand-Sides (LHSs) have proven true. Selection of the appropriate rule to execute is an action called conflict resolution. The most often used technique is rule ordering, where each rule is previously assigned some priority value and the rule with the highest value is executed.

EMYCIN, and hence DECAIDS, is primarily an action-driven system. A premise is presented to the system to be evaluated either true or false. The premise may be proved true by the user providing an answer to a question or through deductive inference. The method for determining a value for the premise is to examine the actions of rules to locate one which will make the premise true. All clauses of the premise must prove true. The following is an example of an action-driven problem solution:

DATABASE: A F

RULES:	1.	A & B & C	= D
	2.	D & F	= G
	3.	A & J	= G
	4.	B	= C
	5.	F	= B
	6.	L	= J
	7.	G	= H

The goal is to prove H true. The system first checks the data base to find H. If this fails, which it does here, the system tries to deduce that H is true by using the rules that contain H on the RHSs. The first relevant rule is 7. G is next sought in the data base since if G is in the data base then H is true. Therefore, rules containing G must now be tried. Rules 2 and 3 apply and these may be assumed to be rule ordered. D and F must be proven and this is accomplished via proving A true in the data base, B and C are true from 5 and 4, and, finally, D and F are true, G is true and H is true. As the rules are executed, the newly proved elements are added to the data base (Waterman, 1976:6). This simple example of an action-driven system is duplicated over and over when evaluating the DECAIDS production rules.

There are two underlying concepts that need to be reviewed, if not understood, when dealing with AI production

systems. They are predicate calculus and the AND/OR tree structure. Predicate calculus is a system of logic used to express complex logical statements as well as mathematical and natural language statements. The system defines rules of inference that permit logical deductions of new conditions based on current states or conditions. Predicate calculus' generality and logical power are important vehicles for performing deduction (Nilsson, 1978:1-45).

AI production systems are based on the formulas of the predicate calculus. A production is a rule consisting of a situation-recognition element and an action element. Thus a production is a situation-action pair in which the recognition element (usually called the Left Hand Side) is a list of conditions to ascertain or test and the action element (Right Hand Side) consists of a list of things to do or conclude. A list may be composed of only a single element or may contain several hundred elements. When productions are used in deductive systems, the situations that trigger a production, or rule, are specified combinations of facts. The actions are assertions of new facts deduced from the triggering combinations. The action of triggering premises and conclusions is based upon the use of predicates and predicate calculus logic. Production rules when triggered are spoken of as "firing" which refers to the action taken by predicate functions (Waterman, 1976:6).

A programming language, using the predicate calculus logic, and specified by some syntax, is used to make assertions about a domain of interest, i.e. provide state descriptions about which some conclusions can be made (Winston, 1977:257). The class of expressions referred to as well-formed formulas (WFFs) is the basis for the assertion clauses of a particular language. The WFFs are used as the contents of a knowledge base and are permitted values of true or false. Techniques for manipulating WFFs permit an AI program to reason about a domain and ultimately reach a conclusion (Nilsson, 1971:87-115). The method of operation is that WFFs are applied, modify a knowledge base and eventually meet some termination condition(s).

The well-formed-formula (WFF) is given meaning by interpreting it (the WFF) as concluding some fact(s) about a domain of interest or under study. For example, the domain of interest in this research is the set of conditions relative to managerial decision support system capabilities. Conclusions drawn from this domain involve relationships among statements in the set of WFFs.

The WFFs have values of true or false derived from the use of predicates (words or functions which direct some action be taken) whose values in turn may be true or false. The predicates perform the action of mapping elements of the domain (elements in the knowledge base) onto other elements of the domain (actually a local consultation or session data

base). The WFFs are driven by the predicates of a language, the elements in the domain, and the relationships between the elements.

Each WFF can be assigned a value of true or false and are subsequently used in arriving at conclusions and recommendations. The values for a WFF are referred to as certainty factors. Certainty factors are based on probabilistic reasoning and represent a subjective rule weight which may be assigned by a system designer or by an expert from whom knowledge base information is obtained. The WFF (premise) which evaluates successfully provides a value between -1 and 1. Those rules with true premises have their actions evaluated and a conclusion is made with a certainty value which is the product of the premise value times the certainty factor (Davis, 1977).

The concept which results in reaching a recommendation or conclusion is the idea of a WFF being a logical consequence of a given set of WFFs. This is formally stated as the theorem of modus ponens which is: If a statement, A, is valid and A implies a statement, B, then B is valid. The premises of the production rules are the WFFs of the domain of interest. These premises or WFFs may further be divided into clauses representing multiple conditions with each clause being evaluated for its respective true or false value (Nilsson, 1978:1-45).

The implication of the preceding is that a "goal" in the EMYCIN system is the determination of the value of some parameter. This parameter's value is derived as a result of the inferences of the WFFs. Each rule may have one or more clauses in its premise with the clauses of one rule joined by an "AND" or "OR" function or combinations thereof. All conditions in a single premise must be true in order to fire the right-hand-side of a rule. The list of rules is a set of conditions joined by a logical "OR" function. As such, any or all of the rules may succeed and give the subject parameter a value. Which value to present to the consultation system user is a combination of certainty factors, probabilistic reasoning, and expert judgmental knowledge (Scott, 1979).

The concept of AND/OR trees is a tree-structure logic diagram utilized in artificial intelligence applications to depict a graph of nodes representing state descriptions which are parameter values. A tree is referred to as a context (or a context tree depending upon the size of the domain), and state descriptions are the parameters of the context. Parameters in turn may have sub-goals used to determine or trace their values. These sub-goals are additional parameters used in other rules. Values are determined by traversing the tree and applying rules.

The tree traversal method used in DECAIDS is called "backward chaining" and is described as beginning a search at

some goal state and proceeding to some initial state. To be more specific, the hierarchical structure of tree nodes, or state descriptions, where a node may have more than one parent, is properly called a graph. This may be the case with multiple rules applying to a specific situation. In the case of multiple rules, a control strategy must be implemented to select and execute rules in a logical manner. This control strategy must have some system for selecting relevant rules -- some special knowledge of the problem to be solved or how the program works. The control strategy used in EMYCIN and DECAIDS is the listing of sets of rules into groups pertinent to only certain states or declared parameters. This grouping serves to focus the tree traversal towards the desired initial state from some goal state.

AND/OR trees facilitate control strategies in decomposable production systems such as DECAIDS. A decomposable system exists whenever a rule application affects only that component of the global knowledge base (accessible to all rules) used to state a rule's premise. The decomposition of the knowledge base is represented by an atom; one parameter at a time being affected (modified, added, or deleted). A primary benefit of the decomposable system is that redundant paths are not searched resulting in model efficiency.

An example of the decomposition of a production system is a rewriting rule such as B implies C_j which produces a

string of C_j's from some arbitrary string of capital letters. The objective is to establish the sequence of rewriting rules which produces the string of all C_j's. Each step in the sequence is a decomposed part of the system. The premise clause of a system's rules form the AND nodes and junctions of multiple rules form the OR nodes in a tree. Those rules whose preconditions, or premise clauses, evaluate to true provide the path to a desired state (Nilsson, 1978:1-45). This structure of the AND/OR tree is used in DECAIDS to select relevant rules and to calculate the final strength or certainty factor of each rule.

Certainty Factors

Certainty factors used in EMYCIN, and hence DECAIDS, provide a methodology for quantitatively supporting the reasoning of production rules. A numerical value may be assigned to each rule conclusion when that rule is added to the knowledge base. This assignment is done by the rule writer or expert. The value assigned is not considered to be a probability but more of some "expert's" judgmental reasoning, and values are permitted to range from minus one to plus one.

The certainty factors are passed along an AND/OR tree (Davis, 1977:22). The "and" function is a minimization function affecting production rules which contain one or more preconditions or clauses. Minimization is effected by the

fact that the conclusion of a single production rule can never be stronger than the weakest piece of information.

The "or" function is a maximization function. Accordingly, the certainty factors of multiple rules reinforce (or detract from) one another. From any "or" function the cumulative certainty factor is the algebraic sum associated with rules leading to that node. The final conclusion's certainty factor is again the algebraic sum of the rule certainty factors leading to the root node. If a certainty factor falls below .2, an arbitrary threshold for DECAIDS, the conclusion is not utilized and the situation is considered as having no rule to conclude about it (Winston, 1977:245).

Applied Artificial Intelligence

Application of artificial intelligence methods can be found in many disciplines (Nilsson, 1974:778-801). Basic AI methodologies and techniques are grouped into four highly interdependent core areas of 1) heuristic search, 2) modeling and representation of knowledge, 3) computer systems and languages, and 4) common-sense reasoning, deduction and problem-solving. Each of these four areas have direct connectivity to many other fields of application. For example, heuristic search has been used in connection with operations research (Chang and Slagle, 1971:117-128), and

knowledge representation with psychology (Newell and Simon, 1972) and common sense reasoning (Fikes et al, 1971:251-258).

Information processing psychology techniques have been devoted to human perception or problem solving (Nilsson, 1974:780). Directly related is the attempt to capture a manager's perception of an organization and construct a production system to model that perception. Production systems, as noted earlier, can be viewed as stimulus-response systems. Newell and Simon state (1972:803) that they "have a strong premonition that the actual organization of human problem solving programs closely resembles the production system organization." It seems profitable to apply these techniques to examining human decision making in organizations.

Summary

The possible large number of variables necessary to describe how managers perceive their organizational setting and the complex interactivity of the variables cannot be realistically modeled by currently defined manual or computerized models. A review of AI production systems suggests a means to encode and manipulate the previously identified CONDITION --> ACTION statements. Information processing techniques are suggested as a means to examine human decision making.

The following chapter will provide a review of the literature concerning organizational variables and DSS capabilities. It will discuss contingent relationships among variables, provide specific IF CONDITION-->THEN ACTION (production rule) statements, and overall provide support for the validity of this research.

CHAPTER III

TECHNICAL COMPONENTS OF THIS RESEARCH

Introduction

The major technical components of this research include decision science and artificial intelligence (AI). Decision analysis, decision support systems, management science, organization behavior and management information systems are related concepts and an integral part of this research. A brief introduction to decision science is provided followed by a longer discussion of decision support systems and artificial intelligence as they apply to this study. Some examples of AI applications are provided. Finally the controversy surrounding the use of a decision support system to model the organization process is addressed.

Decision Science

Decision science, as a discipline, had its origins in operations research (mathematical and statistical applications) techniques begun in World War II. Recent research and writings are recognizing the need to include the relatively nonquantitative fields of the behavioral sciences. Behavioral scientists propose that decision theory remains the province of organizational behavior and theory. This contrasts with more technically minded analysts who suggest

the discipline is better founded in the quantitative methods of management science and operations research. These arguments illustrate the fact that decision theory remains relatively unformulated.

Decision analysis may be interpreted to be a technology for helping individuals make better decisions principally by structuring the relationships among relevant variables and including both hard (objective) and soft (subjective) data. Complex decision problems are decomposed into more clearly definable components such as options, uncertainties and values; and then structured as formal and dynamic decision models. Implementation is, in many cases, accomplished using a computer with some interactive capability.

Decision science research models include and attempt to integrate a diverse collection of related fields: organizational behavior and theory relating to the structure of organizations and the human leadership role; traditional management science focusing on planning, scheduling, and inventory; the study of information systems, particularly data base management, decision support systems, and office automation; and the psychology of decision processes, with a focus on risk and uncertainty. Marked by such diversity, decision science research has a unifying theme: understanding and improving decision-making support. The various desciplines underlying the decision sciences

contribute to this objective, not only separately, but synergistically. For example, research in:

- decision processes provide new knowledge about how to adapt problem-solving methods to the needs of the decision-maker,
- management information systems (MISs) investigates how to best provide information for organizational decision-making,
- operations research/management science (OR/MS) studies formal models and methods for structuring and solving certain classes of managerial problems,
- social science, especially the behavioral areas, provides insight into the results of human interactions, and
- decision support systems (DSSs) carry the promise of integrating these areas through interactive computer-based models.

Decision science research is an effort to provide a synthesis of the human, the machine, and manipulative designs for decision assisting systems.

Decision Support Systems

Lee (1975:480-481) describes the need for applying decision science techniques to analyze organizational decision making constraints. These constraints include specific entities such as the individuals, groups (dealers

and customers), corporate structures (policies), and environmental conditions. The design of an operational model that incorporates these various ingredients vital to the survival of an organization and can prescribe useful decision assisting tools will not only contribute to organizational health but provide an extension of decision science theory. In addition, combining the research of the decision sciences will provide additional bases to support the approach to the contingency theory of management as described by Luthans (1976:28-54).

Decision support systems, in the context of this study, imply the use of computers to assist managerial decision making in semistructured tasks. The DSS is intended to emphasize support rather than replacement of the manager's judgement with an overall goal to improve the effectiveness (vice efficiency) of decision making. DSSs are considered different from MISs or OR/MS tools in that the DSSs:

- are under the manager's operational control, not the control of an information system's staff,
- impact on not-well-structured decision areas, and
- extend management's capacity to formulate answers to "what if" questions.

There are many examples of the design and application of DSS type systems (see Hart, 1978; Little, 1975; Meador, 1974; and Kruzic, 1978). The distinguishing features of the decision support system strategy are that:

1. the user (manager) is, or was, operating under pressure in a complex task,
2. the DSS incorporates a detailed methodology by defining and assessing the process of managerial decision making,
3. the decision processes are multi-dimensional, multi-objective, and only a part of the task can be automated (computer support is used to manipulate data and display information),
4. the DSS technology provides managers with access to computer power, gives fast response, and is easy to use, and
5. computer support, carefully matched to the decision problem, the decision maker's ability, and the decision context, substantially helps the manager.

Artificial Intelligence

Research in DSSs has been concerned with creating a meaningful dialogue between designers and users of interactive computer-based systems. The development and use of computer-based "expert systems" to support DSS designs may be the first step toward integrating the technologists, researchers and users (Feigenbaum, 1978). An expert system can be described as a computerized system that relies on the incorporation of a large amount of human knowledge in a data base which can then be interrogated to provide suggested

actions or decisions. These systems often use techniques of artificial intelligence (AI), such as production rules, to provide choice options to the decision maker.

AI is the study of ideas and processes which enable computers to perform some activities similar to the way humans perform them. Two goals of artificial intelligence are to make computers more useful, and gain a better understanding of intelligence for its own sake (Winston 1977:1). Much of the work in AI represents a simulation of mental activities performed by a decision-maker in order to accomplish a task or achieve a goal.[1] This is done by providing a detailed description or mapping a process, then translating the resultant steps to computer algorithms.

Artificial intelligence has also been decribed by Nilsson (1974:778) as the science of knowledge. His viewpoint is that since artificial intelligence's subject matter is all of thinking, it does not belong to a specific field but is encompassed by all fields as AI is continually applied.

In most AI applications knowledge that is specialized to a particular problem takes the form of "rules-of-thumb" or heuristics so that the search for solutions need not be fully exhaustive (Kaiser, 1978:231). By following these rules, it

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[1]See Nilsson, 1974, for an excellent overview of artificial intelligence and a historical perspective on artificial intelligence research.

is not necessary to explore every possible alternative, but only those which will help limit and direct the search. There are two ways this is usually approached: 1) state-space: one of finding a path through a space of initial conditions and states to a final goal; or 2) problem-reduction: where a problem is broken up into subproblems which are continuously reduced until known solutions of these are found. These methods, using heuristic search, are based on the idea of looking for the most efficient way to handle problem-solving by finding an optimal path.

With very large problem spaces such as those with which managers and researchers must deal, it becomes costly to determine exact solutions. A contingency model which incorporates heuristic search strategies could provide an efficient capability to examine organizational complexity.

A heuristic has been defined by Newell (1963:114) as a process that may solve problems but offers no guarantee of doing so. If it could be proven that an exact solution exists, then this becomes an algorithmic rather than heuristic search procedure. Determining satisfactory solutions to certain problems may be just as important as finding the optimum solution (Lee, 1975:474). The use of computer based heuristics enables intelligent searches for satisficing strategies without the requirement to have the most detailed, current data base available. Most managers

operate under a similar strategy but at a much slower, less thorough and less structured manner.

Artifical intelligence can improve the symbiosis of both man and machine by combining the best characteristics of both. It can take a problem-solving system (see Mitroff, 1976:57, for example) and suggest solutions to large complex problems.

Examples

An AI expert system is illustrated by the MYCIN program developed at Stanford University (Shortliffe, 1976). MYCIN is an interactive, question-answering, computer system which involves the user in identifying specific infections in humans. It then provides suggested diagnoses and treatment. MYCIN integrates the ability to answer the question "Why?" during and after each exercise. It will also store and retrieve cases for future reference. MYCIN incorporates the concepts of decision analysis within the framework of artificial intelligence production rules. Expert opinion was, and is, provided by medical doctors who specialize in the field of microbiology.

Another illustration of applied AI is Tonge's (1963:168-190) assembly line balancing program. This was an early work which used the heuristic of finding a satisfactory solution within some range of the optimum rather than using excessive computing power to attain the optimum. Felsen

(1975:581-598) has done some work in heuristics as applied to reduction of uncertainty in a special decision process of portfolio decision-making similar to Clarkson's (1963:347-374) trust investment model.

The Portfolio Management System (PMS) like MYCIN, was designed and implemented with specific user requirements defined (Keen and Scott Morton, 1978:101). The PMS is a computer driven, graphics display system with a variety of fairly simple models operating from a large, complex data base. It is designed primarily to be used by investment managers of large banks. While PMS is considered a DSS, as is MYCIN, their structures are totally different yet the results are very similar, i.e. direct support for the decision making function.

Wong and Mylopoulos (1977) suggest that data base management systems (DBMSs) and artificial intelligence have much in common. They state that DBMS users are beginning to realize that abstract information should be included in data bases for users. Artificial intelligence has typically manipulated the more abstract type of information.

Travel itineraries are discussed in an intelligent planning system (Sproull, 1977) and an interactive procurement system was developed using artificial intelligence methods (Bosyj, 1976). In the natural language area an interactive system was developed to meet the need of

managerial decision-making dealing primarily with transactional data. This level of data is the basis of answering strategic questions (Malhotra, 1975). PROSPECTOR is a computer-based, natural language, consultation system used by geologists in mineral exploration (Hart, et al., 1978). This computer program has a knowledge base of models containing geological information and provides expert consultation based on varieties of geological evidence.

Williams (1978) provides generic descriptions of other similar but different decision aiding technologies. In one case decision structuring was used to aid decision making with respect to movement of a large naval force to evacuate personnel (civilian and military) from Lebanon. Another DSS, based on prioritization schemes, was used to prepare budget submissions to Congressional committees. These examples illustrate how organizational management was provided an extended capability, through the availability and use of an automated DSS, to manage resources under continued conditions of uncertainty and tension.

Decision analysis techniques have been applied to a diverse set of areas in both the public and private sectors (Van Orden, 1978:38-39). Business decisions have included capital investments, start/discontinue products, price changes and marketing decisions. The areas of treaty negotiations, national security analysis, source selection

and resource allocation in various Department of Defense agencies have also been supported by this methodology. A logical extension of this technology should be to help a manager to determine when, where and how to use decision analysis.

Controversy

A certain amount of theoretical controversy surrounds the subject of this study. Early MIS efforts were highly criticized for advertising a capability beyond anything that could be delivered (Dearden, 1972:90-99). Clearly, Dearden has identified many weaknesses such as the "total" systems approach, falacious centralization arguments, homogeneity of management information, etc., in the optimism of some technologists. While Dearden attempted constructive criticism of MIS, others, in many areas, seem to go beyond criticism, displaying resistance to change in trying to introduce MIS and DSS technologies or even learn about them.

Van Erp (1979:13) notes that in some industries the label MIS is rarely used because it has so many negative connotations of what seem to be unattainable goals. MISs in general have not been able to totally satisfy the pyramidal structures suggested by Burch and Strator (1974:57,76). Management at the mid and top levels of the organization pyramid are not being informationally satisfied.

Dynamic modeling of complex environments is becoming more and more important. Consumerism, inflation, broadening regulation and increased competition make "innovation a key factor for successful companies," (Van Erp, 1979:13). Communicating concepts of various systemic interactions may be facilitated by designing simple or intricate models, unfortunately, there are very few paradigms rich enough to accommodate Van Erp's design variables.

There is a dearth of operational models for complex designs. In many disciplines it has been the case that conceptualization of system interactivity is best communicated by construction of a descriptive model. An almost infinite variety has been and are being created. This includes models from the fields of management science, organization theory and behavior, and management in general.[1] To a great degree the management science (MS) models have been automated or mechanized. An explanation of this is that the structuredness of the MS approach is such that only problems or situations amenable to, i.e. well structured, quantification are pursued.

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[1]For examples in Management Science see Minieka, 1978:20; Harley, 1976:27-34; and Brown, et al, 1974:36. For organization behavior and theory see Lawler, 1973:3; Leavitt, 1970:198; Monczka and Reif, 1973:11; Hodgetts, 1975:377; and Evan 1976:140-141. For management see Luthans, 1976:48-449; French and Bell, 1973:78; and Jenkins, 1977:188.

The majority of the theories concerning organization interactions, especially the ill-defined decision making areas, have not been operationalized. Interactions of different variables experience a complexity that defies the algorithmic approach required of current automated models. Ein-Dor (1978:1064) notes that the variable aspects of organizational (MIS) characteristics could not be effectively modeled. Unless and until a methodology is devised to operationalize complex organization models many theories will remain untestable. A plethora of diagrammed concepts exist whose only claim to validity rests on various field or laboratory studies or the author's personal notoriety. A general methodology which would provide the initial capability to automate these concepts would be very valuable.

Decomposition of organizations into subsystems is necessary in order to identify how they work. Leavitt (1970:198) used the variables structure, task, technology and actors (people) to explain how organizations operate. Various others have used group (Tannenbaaum 1966:57-70), environment (Churchman, 1968:35), task (Argyris, 1975:265) and individual (Porter, 1975:26-26,28) as essential variables to describe organizations. The construction of a framework consisting of relevant variables with their interactivity depicted is a necessary first step to examining decision making requirements and the results of those decisions.

The lack of and need for communication between the researcher and user community was noted by Dr. Davis (Walsh, 1979:25) in discussions concerning technology transfer. A great degree of concern is being voiced at high government levels concerning the inadequacy of today's rate of growth of technological capability on the one hand and lack of its introduction into business on the other. The following illustration is a good example.

On 13 November 1977, the Washington Post featured an article on Zero Base Budgeting. An Office of Management/Budget Official was quoted as follows, "We're really getting a lot better impression of priorities here than we ever did before. If a cabinet officer ranks a program fourth out of 265 programs, it tells us one thing. If he puts it third from last, it tells us something else." This official was impressed with the information he was getting. He was apparently unaware of the vital information he was <u>not</u> getting! For example, the priority list told him the <u>order</u> of importance of the programs in the sponsor's mind, but did not explain the <u>difference</u> in importance between a specific program and the one just above (or below) it. Conceivably program number 3 is twenty times more important than program number 4, but number 5 is about equal in information to number 4. It is evident how valuable this additional information would be to a decision maker allocating marginal resources among competing programs.

A model has been built and tested in a research environment that could possibly be used by this manager "if he knew of it." The resource allocation model (Amey, et al., 1979) is ideally suited for this application, however, the lack of communication and understanding between the user and research communities has presented a barrier.

An illustration of the non-communication concerns a principal technology investigator under contract with the Defense Advanced Research Projects Agency. This work, on a natural language, is conducted within a laboratory environment.[2] When his system was first demonstrated to a group of potential users, military officers at the Naval Postgraduate School in 1978, there was general consensus on the validity of the research, i.e. the potential users visualized its potential. However, the phraseology and mechanics of the system were deemed irrelevant from the potential users' perspective. This was the first time in the 2-3 year development cycle that the researcher had communicated with the user!

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[2]Natural language research in this context is an effort to enhance the human-computer interface by providing a capability to communicate with the machine in human-like languages versus a programming language. In this research English sentences are typed at a computer terminal and the system translates the sentence and accomplishes the appropriate tasks. Natural language refers to the "natural" use of the English (or any other) language.

The expanding role of computer applications and concurrent reduction in the cost of hardware has greatly broadened the views of both the technologist and user communities. Coupled with changing environments, better educated users, more advanced techniques, tight economies, and ever narrower profit margins, increasing the effectiveness of decision making is a high value item.

Technology alone is not enough to satisfy information needs because the dynamics of today's organizations do not permit such independence. Theoretical issues of organizational phenomenon influence the construction and use of various aids (Nolan, 1975). Until relevant organizational variables can be identified and their interactiveness described in some way very few executive level decision aiding systems will evolve. A marriage of the technologies (decision support systems, computer science, behavioral science, artificial intelligence) and technologists (behaviorists, organizationalists, computer scientists, operations reserachers) with the management community (problems, processes and people) is necessary to design, build and operationalize a model as described in this research.

The following chapter will describe the variables (group, environment, task, structure, individual and technology) used to construct a theoretical model. In

subsequent chapters it will be shown how the model can be operationalized and manipulated through the use of artificial intelligence techniques and interactive computer systems.

CHAPTER IV

ORGANIZATIONAL VARIABLES AND DECISION SUPPORT SYSTEM CAPABILITIES: A LITERATURE REVIEW[1]

Introduction

GETSIT is a derivation of the six organizational variables, Group, Environment, Task, Structure, Individual and Technology, selected for this study. The following sections articulate the research pertaining to each variable, identify their relationships with one another, provide operational definitions, and suggest a variety of IF-THEN production rules for possible incorporation in the DECAIDS model. The final section provides a review of decision support system capabilities and contains an additional set of production rules.

Initial model assumptions are obtained from this literature review with refinements introduced from the structured interview, described in a later chapter. Since each GETSIT variable is, in reality, a continuous function the following sections are somewhat artificially bounded; however, it is assumed the reader understands this restriction. The results of the literature review are

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[1]References to general works, used extensively in this chapter, will omit page numbers; however, the more specific citations will continue to be explicitly identified.

presented throughout this chapter in the IF CONDITION-->THEN ACTION production rule format. As such they are directly available for introduction to the DECAIDS knowledge base.

Operational Definition

Operational definitions are among the more confusing aspects of research design, primarily because the term itself is formidable and not because the concept is so difficult to understand. The notion was introduced by the philosophic school of Logical Positivism[1] which sought to clarify language in a rather drastic way, by removing from it all speculative and non-observable words. Such clarification sought to make scientific communication more direct, clearer, and easier to understand so that studies could be exactly replicated.

To achieve such clarity, concepts are defined in terms of the operations by which they are measured. Thus, length would be defined as the number of times a yardstick matched the object being measured. Operational definitions can be

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[1] Also known as scientific empiricism, logical positivism is a relatively modern school of philosophy that attempted to introduce the methodology and precision of mathematics and the natural sciences into philosophy. The movement began in the early 20th century and is considered the fountainhead of the modern trend that considers philosophy analytical, rather than speculative, inquiry. For works see A. J. Ayer, (ed.) Logical Positivism, 1959, E. Gellner, Words and Things 1972, and B. R. Gross, Analytic Philosophy, 1970.

made to apply to many different things including, for instance, a concept such as group.

Group is the first GETSIT variable and is explained in detail later. Defining group by a synonym or by philosophical analysis is confusing because everyone begins with a different idea of a group. But when one defines group by referring to a particular instance of it, for example: "the corporate officers of the First National Bank..." clearly that notion is distinct. Only by pointing directly to some specific example can it become clear exactly what the researcher means by a term. Schonberger (1979) provides an example by describing a fish tank, stating the particular kind of fish, dimensions of the tank, specific characteristics of its construction and its contents.

Operational definitions should, therefore, always point to a specific example or "referent." Chase (1966) lists four possible kinds of referents that could serve as the basis of operational definitions.

These are:

1. Material objects at given places and dates: This cat here. This apple. This woman named Susan Jones.
2. Collections of objects at given places and dates: The people in Madison Square Garden on the night of January 6, 1937.

3. Happenings at given places and dates: Airship Hindenburg burns May 6, 1937 at Lakehurst, New Jersey.

   Napoleon evacuates Mowcow, 1812.

4. Processes verified scientifically: Ethyl ether boils at 34.5°C. All bodies fall with equal velocity in a vacuum.

A fifth kind of more subtle but equally valid referent is suggested by Francis (1978:64).

5. The personal experience of a given individual as reported by that individual.

The following discussion of GETSIT variables, group, environment, task, structure, individual and technology, provides both an indepth review of the literature as well as operational definitions for each variable. In view of the many authors who have conducted research in these six areas more than one operational definition may be provided. Since DECAIDS is structurally composed of combinatorial heuristics and production rules it can deal with such multiplicity. It is hoped that the reader has a similar ability to concurrently manage this variety.

Group: Definition

Webster (1966:641) defines a group, in one sense, to be a number of persons classified together because of common characteristics. Cartwright and Zander (1968:46) adopt the following definition.

> "A group is a collection of individuals who have relations to one another that make them interdependent to some significant degree. As so defined, the term group refers to a class of social entities having in common the property of interdependence among their constituent members."

Elaborating further they (Cartwright and Zander, 1968:48) stipulate that "when a set of people constitutes a group, one or more of the following statements will characterize them; (a) they engage in frequent interaction; (b) they define themselves as members; (c) they are defined by others as belonging to the group; (d) they share norms concerning matters of common interest; (e) they participate in a system of interlocking roles, (f) they identify with one another as a result of having set up the same model-object or ideals in their super-ego; (g) they find the group to be rewarding; (h) they pursue promotively independent goals; (i) they have a collective perception of their unity; and (j) they tend to act in a unitary manner toward the environment."

The term, group, represents a number of individuals acting together to accomplish a common task. Within an organizational structure these groups may be formal or informal, permanent or temporary, and large or small. Actions and decisions of the group are affected by group norms, social pressures, power and influence of group memberships, leadership, performance of group members, motivation processes and communication patterns (Filley, 1976:470; Cartwright and Zander, 1968:139-140; 215-216, 301-302, 401-402, 485-486).

Schein (1970:8) proposes that division of labor, a mainstay of organizational structure, provides the basis for groups to form. An important definitional concept of a group is that the size of the group is limited by the possibilities of mutual interaction and mutual awareness. This definition precludes such entities as unions and organizational departments from being considered groups. Another important attribute of groups is that they tend to provide safety for the individual from what Blauner (1964) calls patterns of alienation. This alienation includes: 1) sense of powerlessness or inability to influence the work situation, 2) loss of meaning in the work, 3) sense of social situation, 4) lack of feeling of belonging, and 5) self-estrangement or the feeling that work is merely a means to an end. Schein (1970:84-85) concludes that groups provide:

a. "an outlet for affiliation needs, i.e. needs for friendship, support and love,

b. a means of developing, enhancing or confirming a sense of identity and maintaining self-esteem,

c. a means of establishing and testing reality through developing concensus among group members, uncertain parts of the social environment can be made 'real' and stable, as when workers agree that their boss is a slave-driver,

d. a means of increasing security and a sense of power in coping with a common enemy or threat,

e. a means of getting some job done that members need to have done such as gathering information or helping out when some are sick or tired."

Organizations are composed of variety of group typologies (Scanlon, 1974:69). These include formal groups, informal groups, symbiotic cliques, parasitic cliques and defensive cliques. The formal group is either permanent or temporary but is always a creation of the organization structure. Informal groups arise spontaneously. They may be viewed as either vertical (alliances of former unequals) or horizontal (cut across departmental lines) or a combination of both.

Symbiotic cliques describe groups where the manager aids and protects subordinates in addition to humanizing the work

environment. Concurrently the workers are generally loyal and concerned for the manager's welfare. Parasitic, aggressive and defensive cliques are defined respectively as groups that are 1) lower level groups which receive more than they give, 2) formed to effect desired changes and 3) are formed to prevent introduction of undesired changes.

Katz and Kahn (1966:377-378) relate group cohesion, the amount of "groupness" or sense of mutual identification, to organizational productivity. Various factors which affect the degree of cohesion (Scanlon, 1974:274-5) are:

- dependency - the greater the dependency of the individual on the group then the greater the attraction the group will have for that person.
- size - the larger the group the less cohesive it becomes.
- homogeneity and stability of membership - necessary for long lasting effective groups. Similar interests and background are important.
- communication - if the group communications are good its cohesiveness will be high.
- isolation - if members are isolated from the group cohesiveness tends to be reduced but if groups are isolated from the

rest of the organization that group's cohesiveness tends to increase.

. outside pressures enhance group cohesiveness

. competition - intergroup competition increases individual group cohesiveness, however, intragroup competition is very disruptive

. disruptive factors include

(1) members using different tools or methods to solve problems

(2) differences regarding goals

(3) individual goals in conflict with group goals.

Gouldner (1954) explained in detail the effect of group cohesiveness, power, and security, in his Patterns of Industrial Bureaucracy. The underground miners formed a unique 'group' different than the factory workers and wielded a greater degree of power that demanded a modified managerial approach.

Recognizing that group cohension strongly affects organizational effectiveness a organization's strategy should include measures to reduce intergroup conflict before it can start (Scanlon, 1974:276). Four steps to accomplish this are:

1. provide emphasis on total organizational effectiveness,

2. give organizational awards based partly on assistance groups provide each other,
3. frequent rotation of members among groups to stimulate understanding, and
4. avoid win-lose situations.

In addition to cohesiveness, group norms are conceptually important. Several researchers, Mayo (1931), Likert (1961) and Seashore (1954), note the tremendous impact that group norms, loyalty and solidarity, have on overall productivity. These norms are the standards of conformity or behavior expected by the group of its members. These norms provide two important functions (Scanlon, 1974:276). The first is to help the group accomplish its goals while the second is to strengthen or maintain the group as an entity. The norms (informal rules) and standards tend to mold and guide the behavior of its members. The membership in various organization groups was tentatively categorized by Dickson and Simmons (1970:60). This included operating personnel (clerical and non-clerical), operating management (from first level supervisor through mid-management), the technical staff and, finally, top management.

Group: As an Organizational Variable

Fox and McDade (1978:154) provide some insight concerning the group as a key member of an organization's socio-technical system. Various "coalitions" are described

as controlling entities. Peer leadership is another descriptor for group involvement (Bowers and Hausser, 1977:81). Peer support, work facilitation, goal emphasis and team building are intimate characteristics of a well functioning group.

Tannenbaum (1966:57-70), in primarily a process view, indicated the how, as opposed to the what, of groups as a distinguishing organizational variable. He portrayed a vivid picture of how the group impacts an organization in both positive and negative senses. The bank wiring room phase of the Hawthorne studies is a good example of one group's negative, restrictive power. Production was withheld because of the accepted group norm.

Some important attributes of groups are that they:

1. are ubiquitous,
2. influence employees' perceptions and attitudes,
3. influence the productivity of employees,
4. aid an individual in satisfying unfulfilled needs, and
5. facilitate communications (Donnally, et al, 1971:183).

Through several examples from coal miners to soldiers, Tannenbaum illustrates the power of groups particularly when a threat or danger was perceived by a group member. His research sheds light on two processes that have important implications for organizations. They are conformity, the

conforming behavior of a group member to the norms and standards of that group; and support, the comfort and aid that groups provide.

Three general conclusions concerning the power and influence of the group were listed by Tannenbaum (1966:58-59). They are:

1. The more attractive a group is to members, the more likely members are to change their views to conform with those of others in the group.
2. If an individual fails to conform, the group is likely to reject him; and the more attractive the group is to its members, the more decisively they will reject this individual.
3. Members are more likely to be rejected for deviancy on an issue that is important to the group than one that is unimportant.

Results of a study of the sources of strategic problems in organizations suggests that most problems are caused by groups (Graham, 1977:69). Overall effectiveness of an organization is determined by a variety of factors, one of which is that organization's formal and informal groups (Fox and McDade, 1978:154). Noting the power wielded by groups, organizational change methods have been designed to explicitly address how to handle existing groups. Leavitt (1964:38) suggests that concentrating on changing groups would be an appropriate means of introducing and modifying

the structure and/or technology of a given firm. For example, applied group dynamics have been used successfully as change methods for effecting shifts in power structures (Leavitt, 1964:40).

Groups and group dynamics are considered to be important organization variables when contemplating organizational change and intervention (Luthans and Kreitner, 1975:80). Various approaches, or strategies must be analyzed from the aspect of their impact on the individual in a group, the group, and the interaction with other groups. For example, Dickson and Simmons (1970:61) point out that the middle manager is usually the most resistant to change and suggest the following:

> IF the group consists of middle managers,
> AND change is essential,
> THEN use professional organizational change agents.

Resolving conflicts is a major task for the group composed of multiple decision makers (Campbell, 1975:7). Several methods are suggested. Pennings (1974:394) proposes task-oriented structures be developed by the group to facilitate problem solving (i.e. reduce conflict), while Stead (1978:174-176) recommends nominal and sequential brainstorming techniques to enhance group cohesiveness and

effectiveness. The results of Stead's work provide two decision rules.

> IF nominal brainstorming techniques are used within the GROUP,
> THEN DSS recommendations include individual, interactive capabilities.

> IF sequential brainstorming is used by the, GROUP,
> THEN DSS recommendations include group display with multiple inputs.

He describes a nominal group as a number of people who work in the presence of others but generate ideas independently rather than discuss them. A sequential brainstorming group is a group which participates in round-robin presentations of ideas with a forced participation type of atmosphere.

Johansen et al. (1978:317) discusses problems with the brainstorming technique as a conferencing methodology. Factors that must be considered and handled are definition of the protocols of the conferencing session, i.e. who goes first, agendas, leadership and participant styles and the ultimate impact of group decisions. From Johansen's work the following productions can be implied.

IF computer conferencing is planned,
THEN the following capabilities are required:

1. individual I/O devices
2. real time system
3. time sharing or dedicated on-line system
4. telecommunications.

Additionally Halbrecht (1978:7) suggests:

IF data are from multiple sources
AND group decision making is involved
THEN data fusion techniques should be used.

The dependency and interdependency of the group with other organizational variables has been noted by a variety of researchers. Locander (1979:62) relates the effect of large scale collective interactions (groups) on the organization environment. Fox and McDade (1978:155) associate group activity with organization tasking requirements and technological quality, while Money (1978:136) indicates a direct relationship between the existence of groups and the nature of related organizational structures. Relationships between individuals, tasks, structures and groups is reported by Bedeian (1978:142). Leavitt (1964:31) adds the variable people in his essay on the need to establish a viable

framework for studying complex organizational interactions, and Lee and Moore (1975:480-481) include owners, employers, customers and dealers (all groups) as important, necessary, factors to consider in building an organizational taxonomy.

According to Scott (1967:83) the major element in the formation of groups is interaction. Individuals simply interact with one another to solve problems, attain goals, facilitate coordination, reduce tension, achieve a balance and for physical propinquity. Luthans (1973:443) points out that groups and the informal organization represent two important dynamics of organizational behavior. An informal organization structure composed of groups coexists with every formal structure.

Porter, Lawler and Hackman (1975:368-434) detail how other people (groups) affect work attitudes, beliefs and impact the behavior of the individual. They examine social processes, and conclude that group activities directly impact individual effectiveness in an enterprise and just as directly affect the whole organization. The existence of groups, formal and informal, represents a real and strong influence in the activities and overall effectiveness of an organization. Recognition of the influence of groups is important in attempting to understand how an organization operates and how to enhance its growth.

A concept suggested by Likert (1961:104-105) explains how key members of groups act as "linking pins" to effect

organizational communication and operation. Locander's (1979:62) research supports Likert's concept by noting how the formal definition of group members as "linking pins" greatly enhances task effectiveness through greater coordination, understanding and communication. Improved group understanding and support for overall firm operation are also noted.

Group: And Information Processing

Steering committees are a type of formal group composed of members who have an interest in the subject or project which needs "steering", (Glennon, 1978:79-84). Many organizations form steering groups to guide the planning and development of large important projects such as computer based information systems. The value of this committee is that it provides a forum for each member to present their cases for or against various proposals, to gain insight into other's problems and achievements, and to share expertise. An obvious result of the steering group (also commonly referred to as project team or planning group) is the following rule.

> IF decisions impact several functional areas,
> THEN use of a steering committee is recommended (or project team or planning group).

Ein-Dor's work (1978:1074) strongly indicates that the MIS process is greatly enhanced with the assignment of a steering group with responsibility for the process. Earlier, Dickson and Simmons (1970:6) discuss how groups play different but vital roles in the development and use of an MIS. They point out that each group is affected differently by the introduction and use of computerized information systems. In order to minimize negative group reactions or responses a steering group should consist of managers from various operational and staff departments, especially representatives from the functions directly affected, and information system professionals trained in the analysis of organization systems, information system development, computer technology and management science modeling (Locander et al., 1979:63). A means of accomplishing this (King 1978:31) is to require group participation and involvement in the MIS strategic planning process.

Various MIS researchers have identified the impact of group involvement on the probability of success of various MIS efforts. Franz (1978:01) did a comparison across the variables of individual, group, and organization. He noted that some important group elements to consider were attitudes, satisfaction, group dynamics and functional areas. Bariff (1977:827-8) noted that many groups can be relatively adaptive but sometimes it is the administrator or manager who is not. Recognition of these components and managing their

interactions should increase the chance of success for many projects.

The implication of group decision making suggests multiple sources of data, and in some instances, data and decisions critical to the organization. If the data sources are wide ranging and relatively abundant, a means of filtering is advisable. A rule (Halbrecht, 1978:7) provided earlier in a partial form, is presented in its totality.

IF data are from multiple sources,
  OR group decision making is involved,
  OR decisions are critical to organization,
THEN use of data fusion (filtering, collating)
  is recommended.

Three additional production rules, not previously cited, have been developed by Johansen (1978), Graham (1977) and Lawler (1978). Supportive discussion is not provided but is available from the references. Stated in the following form these data are directly usable as input to the DECAIDS knowledge base.

IF group communication is necessary and
members are geographically separate,
THEN the use of video, computer or audio
teleconferencing is appropriate (Johansen, 1978:314).

IF there are several groups involved,
AND the leader(s) is(are) good problem identifier(s),
AND there are many interaction among the problems,
THEN staff participation should be encouraged in the problem identification process,
AND stakeholders (groups) analysis should be accomplished,
AND pairwise comparisons, eigenvector procedures, and probability estimates are appropriate for the analysis (Graham, 1977:67-72).

IF several decision makers are involved,
AND there exists a variety of objective functions,
AND different measures of effectiveness are used,
THEN static and dynamic game playing with multiple solution outcomes are recommended. Computer simulations and zero-sum games are examples (Lawler, 1978).

Formal and informal groups form as soon as people start to interact. Success in today's society, particularly in organizations, is dependent on the effectiveness and efficiency of networks of groups. It is essential to be aware of the power that groups have and how to best accomplish organization goals through it. The concept of a group is an essential element of the DECAIDS model.

Environment: Definition

The "E" of GETSIT represents facts that influence the organization but are beyond the immediate or positive control of the decision maker(s) (Churchman, 1968:35). The environment may be defined as "the organizations and parties in the raw materials market that supply an organization or function with its input resources and the organizations and parties in the product markets that obtain the output or services..." (Van de Ven, 1976:65). Pennings (1975:393) simply states that "the environment is the organizations' source of inputs and sink of outputs", or the set of persons, groups and organizations with which there are interactions.

All organizations, in varying degrees, are dependent on their environment for survival (Pennings, 1975:393). It is important to understand how the environment is described, understood and how it affects other parts of the firm. Ein-Dor (1978:1066) finds that the environment is best characterized as an uncontrollable variable. His view is that the environment is dictated by extra-organizational factors and beyond the control of the decision maker. Others stress, however, that the environment may be viewed as both external and internal (Graham, 1977:68-69). Graham explains that the external environment consists of problems or situations generated external to the function and forced on it. Government regulations are a good example. The internal environment is composed of internally generated situations

resulting from internal practices, policies and procedures. An example could be an operational policy or procedure over which the decision maker has no immediate, if any, control.

An understanding of the real environment and its potential impact on organizational effectiveness is the subject of study for many researchers. Fox and McDade (1978:154) reporting on their work in information processing contend that not just "the" environment but different environments strongly influence the overall effectiveness of firms. Previous work in decision analysis by Lee (1975:474) reveals the importance of the environment and resulted in efforts to further integrate it with behavioral and quantitative analysis techniques.

As opposed to the real, objective, measureable environment, the perceived environment is perhaps more important. Whallon (1978:157) and Shin (1978:23) studied the concept of uncertainty as a psychological state resulting from the decision maker's perception of the environment. Some of the preliminary results of their work clearly show the importance of understanding that managers perceive the environment differently depending on many different factors, one of which is their level in the organization.

Lee's research (1972:9) shows that decision makers attempt to attain objectives in the most effective manner possible in an "environment of conflicting interests, incomplete information, limited resources and limited ability

to analyze the complex environment." Subjective analyses are forced on the manager by the decision environment. Uncertainty is a multidimensional problem composed of a variety of environmental factors (Whallon, 1978:157). These include span of control, feedback, unknown costs, control predictions, decision difficulty and conflicting internal and external influences.

The following list is composed of various elements which have been proposed and/or studied as viable environmental factors.

Author(s)	Associated Environmental Factor(s)
Ross and Murdick, 1975, p. 41.	Social, political, economic, technological, market pressures.
Duncan, 1972 pp. 313-327. Hall, 1974. Luthans, 1976, p. 57. Kast and Rosenzweig, 1974, pp. 617-618. Negandhi. 1975, pp. 334-344.	Cultural, social, technological, educational, legal, political, economic, ecological, demographic. These could include customers, clients, suppliers, competitors, supervisors, technology, sociopolitical climate and the weather.
Tricker, 1976, p. 129	External: sociological, political and economic factors. Internal: resource strengths and weaknesses, internal constraints, technology, location, size, unions, labor prerogatives, management practices, financial position.
Van de Ven 1976, p.69.	Input resources, labor force.
Pennings 1975, p. 394.	Stability, complexity (differentiation), resourcefulness, competitiveness, uncertainty, information.

Pennings, 1975, p. 401.	Resourcefulness, complexity, competition, organizational intelligence, uncertainty, instability, feedback specificity, demand volatility.
Ein-Dor, 1978, p. 1067.	Availability of 1) trained personnel, 2) hardware, 3) software, and 4) decision techniques.
Hodgetts, 1975, p. 436.	Predictability, technology, turbulence, uncertainty, dynamics, stability.
Cheney, 1978, pp. 173-174.	Stability, complexity, decision making area, decision maker's relative organizational position.
Shin et al., 1978, p. 233.	Social, political, economic, legal, cultural, foreign firms and technology.
Beach et al., 1976, p. 39.	Time, money.
King, 1978, p. 31.	External: goverment and industry reporting requirements, systemic interfaces, clients Internal: People, practices, resources, MIS budget, organization complexity, distrust of sophisticated systems.

Environment: As An Organizational Variable

Competition, demand, resource and capital available are all parts of the environment which affect the organization. Consequences of a multitude of activities external to the company represent real threats to organizational success and existence. For example, the pressures of government regulations (hiring, reporting, etc.), consumer boycotts, safety practices, and conservation groups represent strong environmental forces.

French and Bell (1973:79) suggest that data sensing and collection, resource procurement, output placement or output resource exchange, and responses to external demands constitute a set of variables which make up the external interface subsystem, i.e. environment. In organizational behavior modification techniques, Luthans and Kreitner (1975:132) discuss environment in the context of the work environment. They leave no doubt about the environment having an important impact on organizational life. Perrow (1970:vii) indicates that the environment is one of the elements which must be considered in order to understand and change behavior. His point of view is that it is the interrelationships among several variables and the recognition of that interrelationship that allows us to learn something about organization behavior and "to manage and survive in organizations."

Lawrence and Lorsch (1969) develope a far reaching study on the subject of organizations and their environments. One of their conclusions is that the organization's environment has a great deal of impact on its operation (Lawrence and Lorsch, 1969:5). The study's results concerning the demands of the environment on the organization led Lawrence and Lorsch to the following conclusions.

a. Integration and differentiation are generally opposing forces,

b. More effective firms in a given environment have more integration and differentiation than those firms that are less effective.

c. More stable environments favor the less differentiated and more integrated firms.

d. The appropriate level for conflict resolution is higher for more stable environments.

e. Classical patterns of management, bureaucratic forms, are more often found in stable environments.

Thompson (1967:4) concerns himself with the "natural system" approach to organizations which treats the organization as a unit in constant interaction with its environment. His emphasis is that the organization is to be considered as a complex set of interdependent parts interacting with one another and dependent in whole on some larger environment. Gouldner (1954) provides a dramatic example of the environmental impact on organizational, as well as, individual behavior. His study of bureaucratization of a gypsum plant clearly indicates that organizations must understand and effectively deal with their internal as well as external environments to remain healthy and viable.

In aggregate the environment has been studied and decomposed into many different elements accentuating the complexity of this element. Some evidence exists concerning efforts to relate information systems and the environment. Shin (1978:233) proposes an information system to actually

test a competitive environment. This system would use intelligence concerning competitor activity and, being sensitive to its impact on the organization, would provide planning data useful to alleviate threats and take advantage of opportunities.

Environment: And Information Processing

Cheney (1978:173) describes a research project which attempts to identify environmental characteristics that affect decision making. In particular the effort is to determine elements that will correlate with acceptance and utilization of new information within an organization. Results of the work indicate that the functional work area, the decision maker's position in the hierarchy, the type of decisions encountered, and the degree of stability and complexity collectively determine informational needs. Organizational transfer of information depends heavily on environmental factors according to Cheney.

Identification of the connectivity between the concept of environment and other organizational elements is necessary to establish a basis for building the GETSIT framework. This interaction was identified by Fox and McDade (1978:154) when studying organizational effectiveness. They conclude that environments, constituencies (groups) and socially constructed standards (structures) combine to influence levels of effectiveness. Environmental data must be

processed, for example, for management to assign proper tasks.

Pennings (1975:406) in an examination of a structural-contingency model concludes that there is a high degree of association between structural and environmental uncertainty. Indeed, there were a number of observed correlates. Additional relationships between the environment and technology, task and groups (Pennings, 1975:393-4) are noted. One such is:

> IF predicted or action ENVIRONMENT uncertainty increases in factors such as instability, resourcefulness, demand volatility, competitiveness and complexity,
> THEN STRUCTURE interaction increases in areas of amount of information communications, participativenes, frequency of meetings,. specialization and power equalization.
> (Pennings, 1975:396)

Relationships between groups and the environment have been studied by numerous people. Stead (1978:176) conducted a field study concerning two brainstorming techniques. One conclusion was that with the appropriate environment either or both techniques could provide satisfactory results. Graham (1977:69) studied groups as stakeholders within

organizational environments. He concluded that these groups would in some cases create either a beneficial or detrimental environment for the organization. A similar finding that the group interaction can provide either a positive or negative environment was reported by Locander (1979:62).

The impact of organizational interactivity on information systems is described by MacFarlane (1978:161). Technology, structure and the environment are identified as highly pertinent sources of complex interactions. Slocum (1978:124) identifies individuals, task and technology as members of an environmental "transformation process" while Van de Ven (1976:68) discusses environment, technology, task, and structure dependencies, and Jones (1978:189) introduces the idea of environmental uncertainty, technology and role specialization. In fact, Jones provides the following:

> IF the perceived ENVIRONMENT and TECHNOLOGY are supportive,
> THEN there will be a supportive relationship between the TECHNOLOGY and TASK.
>
> (Jones,1978:189)

In a view of organization design Ginzberg (1978:40) suggests the inter-connected elements of task, technology, structure and people. The results of this consortium and the resultant interactivity produces a decision-making

environment. However, as Ginzberg explains, the environment imposes new tasks on the organization and introduces the need for change among the four original elements. This is an illustration of the dichotomy of external vice internal environments.

We have looked at a variety of definitions of environment, different studies applying the concept, and some relationships with other variables. From the literature the following additional production system rules may be derived.

> IF ENVIRONMENT allows multiple decision makers,
> AND each INDIVIDUAL has equal influence and power,
> THEN the CONSENSUS process performs well,
> AND GROUP decision making is recommended.
> (Nackel, 1978:1266)

> IF the ENVIRONMENT is dynamic,
> THEN the INDIVIDUAL and GROUP decision making time frame tends to be much shorter than in less dynamic conditions.
> (Ein-Dor,1978:1069)

IF the ENVIRONMENT is dynamic,
OR TECHNOLOGY is high,
THEN adaptive organization STRUCTURE is recommended.

(Hodgetts, 1975:436)

The environment has an effect on and is affected by a number of organizational elements. It is not independent of and yet not totally dependent upon other attributes of a firm. An operational definition has been provided with supporting discussion. The interactions of the environment are both complex and numerous. Several production rules (IF CONDITION-->THEN ACTION) conclude the section.

Task: Definition

The task is the organizational process that must be accomplished in order to satisfy corporate goals. Performance of the task is the primary reason for organizing (Ross and Murdick, 1974:41). The task has been identified as an important organization variable and has a strong influence on the overall structure of the organization as well as on individual and group behavior (Argyris, 1975:265; Drucker, 1974:61; Gouldner, 1954: Trist, 1975:345-369).

Fox and McDade (1978:155) describe the organizational task as the INPUT-OUTPUT transformation process. Included in this definition is the underlying assumption that top management's role is to process environmental data, define goals (assignment of tasks) and adapt the organiztion structure to accomplish them. The organizational raisons d'etre are its tasks (Leavitt, 1964:31).

Tasks assume various characteristics. Griffin (1978:118) discusses varying degrees of variety, autonomy and feedback as important aspects of task. Van de Ven's (1976:69-71) research in organization assessment resulted in providing descriptions of task components. Included are task difficulty, variability, specialization and standardization. Difficulty determines the amount of expertise and discretion needed to perform the task. Variability, defined as the number of exceptions in the activity, is the degree to which work processes can be structured in a systematized,

routinized or mechanized way. On the other hand, standardization is the degree to which these processes are or can be specified in such detail that standard procedures, rules, etc. can be established to guide task performance. Task, or role specialization is that group of subtasks over a range of tasks that are delegated to specific individuals.

The importance of task as an organizational variable has been stressed by Drucker (1974:36). He proposes that it is only through terms of performance dimensions and performance demands that the organization can be understood. "The tasks of management are the reason for its existence, the determinants of its work, and the grounds of its authority and legitimacy." For example, the economic performance of an enterprise can be considered a primary task of that organization. The second and third tasks decribed by Drucker (1974:40-41) are

2. "to make work productive and the worker achieving," and

3. "managing the social impacts and the social responsibilities of the enterprise."

Task: As An Organizational Variable

The organizational task is dependent upon and depended on by a large but finite number of other organizational variables. To a great degree it is the magnitude and amount of interaction that produces the complexity which eludes

definition. A considerable amount of research is available concerning this complexity and is reviewed. For example, Graham (1977:68) notes how the interactions of organization variables do not exist in isolation and a change of state in one will affect the others.

The degree of stress on the task variable correlates with the planning, execution, and evaluation phases of goal attainment. The planning phase generally involves tasks that are nonstressful, although some objectives may necessitate short-term planning in a constrained time frame. Execution phases may require high risk choices within the short term. These tasks call for real time or near real time decisions and thus possess high stress. During an actual military operation, for instance, unforeseen events that cause a commander to immediately redefine the course of action may occur, such as accidents, loss of resources, and strong enemy actions. In addition to short-time decisions, such stressful situations may evoke the affective states of pain, fatigue, and sorrow that tend to heighten the complexity of rational decision-making (Stanford Research Institute, 1974).

Requirements involving evaluation tasks are often of a nonstressful nature. This phase provides feedback to the decision-making team on the planning and execution phase so that lessons for future tasks are available. Thus, evaluation tasks generally do not involve excessive time constraints or risk. However, in an ongoing operation,

evaluation tasks may involve short-time, stressful behavior to discern the success of previous actions and decide on the course of an immediate, subsequent action.

Organization tasks that are exceedingly stressful in terms of time constraints on decision formulation or high risk alternatives are likely to require different informal organization structures than low stress tasks. Experimentation has indicated that psychological stress results in high personal anxiety, fear, defensiveness, and adherence to past successful methods of problem-solving even when they are inappropriate (Cowen, 1952:512-519, Spector, 1975). Such decision-making ridigity is usually relieved in low stress task environments. Special types of personnel arrangements are usually required to cope with the psychological effects of stress.

Argyris (1975:265) considers the element, task, to be one of the basic principles of formal organizations, particularly the specialization of tasks. He stipulated that "if concentrating effort on a limited field of endeavor increases the quality and quantity of output, organizational and administrative efficiency is increased by the specialization of tasks assigned to participants of the organiztion." Task specialization directly impacts structural elements such as chain of command, unity of direction and span of control. Examples of this are provided by studies (Gouldner, 1954; and Trist, 1975:345-369) which

compared gypsum plant workers and miners in one case and pre-mechanized versus post-mechanized coal mine operations in another. In these cases the task was the driving force which determined both the accepted task structure and individual/group behavior.

Delegation of authority and span of control are factors determined primarily by the task(s) to be performed. According to French and Bell (1973:78) the task subsystem consists of task and subtasks. This subsystem or sub-task network represents the total work or process that needs to be performed to produce some end product. Technology (the kinds of machines, tools and skills used) extensively influences the task performance and is discussed at greater length elsewhere in this paper.

Luthans and Kreitner (1975:80) consider the nature of task a major environmental variable. In this approach, the theoretical application of behavior contingency management (BCM), the nature of the task is extremely important since some tasks lend themselves to behavioral interventions and some do not. Not only the task, but task interaction with other variables (in this case structure, technology and groups) is extremely important.

Task is sometimes used to identify leadership traits. Characteristics that are identified by Stogdill (1974:75) as being task related are:

achievement drive or desire to excel,

drive for responsibility,

enterprise, initiative,

persistence against obstacles,

responsibility in pursuit of objectives, and

task orientation.

Identification of certain aspects of organizational tasks can in itself be a major task and a most important one. The relating of tasks to workers by some type of selection is also important. There should be a definite attempt by the employer to match the psychological make-up of the prospective employee with the psychological demands and opportunities of the job as well as trying to match skills available with skills needed.

Concurrent with personnel selection and matching (or task/structure modification) an important consideration is selecting and developing an appropriate authority structure (Lichtman, 1973:237-255). The degree of task interdependence must be an integral part of this consideration because the greater the congruency of power the greater the frequency of desired task performance. It has been demonstrated that when there is a high interdependence of tasks and creative requirements are minimal then a hierarchical authority structure is appropriate. However, if the opposite is true, a low interdependency and requirements are relatively

non-creative, then a democratic authority style should be used for maximum efficiency.

It is necessary to realize that structural adaptability is necessary where and when there is significant task uncertainty. As Bennis (1973:327-338) indicated organization structures of the future will need to become adaptive to accommodate rapidly changing, temporary systems of tasks. Good examples of this can be seen by looking at industries, such as the TRW, with matrix or project type organization and the high technology adaptability of the Texas Instruments and Boeing Aircraft Companies. Organizations tend to build structures around tasks which involve problems to be solved. Galbraith (1974:29-33) suggests:

> IF the TASK uncertainty increases,
> THEN an increase in coordination STRUCTURE is neccessary.

Fiedler (1968:369) identified a connection between the leader's effectiveness and the task in group situations. He said that "the leader's effectiveness is defined in terms of the group's performance of the primary task." Guetzkow (1968:512-526) made a direct connection between task orientation of the individual, leadership within groups and interlocking roles defining organizational structures. While structure is discussed as a major organizational variable

elsewhere, it is important to retain an awareness of the interdependencies of the various organizational elements.

Hollingsworth (1975) proposed models depicting the formal and informal organization, and a combination of the two indicating the interaction which does and must occur. Task is identified in each of these as an integral part to be recognized and understood by the manager. Once so recognized, the possibility presents itself for more effective managerial decision making.

Leavitt's work (1964:30) in organization change resulted in framework which described the interaction of tasks with structure, technology and people. Each of these elements may play either a positive or negative role but their synergism determines overall organization effectiveness. Ginsberg (1978:40) uses Leavitt's framework to discuss various designs to enhance use of decision support systems. He added the category of environment in suggesting that "the environment imposes new tasks on the organization,..."

A prime determinant of the corporate structure is the general nature of the organization's task. For example, the introduction of new technologies will generally require some modification to work behavior and the development of new tasks enables the organization to remain effective. The definitions of certain tasks, as well as the way they are done, is at times necessary to successfully use new systems

(Ginsberg, 1978:40). The following production rule is a result of Thurber's work (1978:18) on task and structure.

IF TASKs are highly complex,
AND are interrelated,
AND competing for resources,
THEN a matrix STRUCTURE is appropriate.

IF TASKS are well defined,
AND clear,
THEN traditional STRUCTURE is appropriate.

Tasks provide stimuli to individuals (Griffin, 1978:118). Griffin's research suggests that different people respond to different stimuli. Tasks with a high degree of stimulus will be preferable to some while others require low or moderate stress stimuli. The most basic individual-organization relationship is probably between the person and their task. According to Griffin (1978:118), "the nature of this relationship will probably have a direct impact on the manner in which the employee responds to other organizational factors." One example provided by Biggs (1978:21) is:

IF the TASKs is/are dynamic,
AND ill structured,
AND the project leader INDIVIDUAL is unskilled in group decision processes,
THEN participative decision making is not recommended.

Research supports the assertion that greater individual-task congruence will exist when the needs of the individual match the motivational characteristics of the tasks to be performed. Griffin (1978:119) provides an example of this in a discussion relating low and high scope tasks to growth needs of leaders. From this we deduce the following:

IF the scope of the TASK is high,
AND the worker has a high growth need,
THEN either an achievement-oriented manager INDIVIDUAL,
OR a participative manager INDIVIDUAL is recommended.

IF the scope of the TASK is high,
AND the worker has a low growth need,
THEN a directive leadership INDIVIDUAL is recommended.

IF the scope of the TASK is low,
AND the worker has a high growth need,
THEN a supportive leader INDIVIDUAL behavior is recommended.

IF the scope of the TASK is low,
AND the worker has a low growth need,
THEN a minimum interference INDIVIDUAL leadership style is recommended.

(Griffin, 1978:119)

Bedeian (1978:142) studies the relationships of various organizational factors and concludes that task is a vital ingredient in assessing overall organizational climate. He identifies satisfaction, tension performance and propensity to leave as components of task. In addition, Bedeian proposes there is a strong relationship among the task, group and structural elements of an organization. In support of this Leavitt (1964:33) notes that "...early structural approaches always mediated their activities through people to task."

Contingency theorists are having a lively debate (Van de Ven, 1976:68) concerning the primary determinant of organization structure. Task is one of the strong contenders, along with environment and technology.[1] Task is also a key element in Slocum's (1978:124) technology model. Not only does he directly tie task and technology together but he includes individuals and groups as well. For example, the following rules may be extrapolated.

IF the TASK is predictable,
THEN the TECHNOLOGY is probably stable,
  AND the GROUP is probably weak,
  AND the STRUCTURE is probably centralized,
  AND the ENVIRONMENT is probably stable.

IF the TASK is uncertain or unpredictable,
THEN the TECHNOLOGY is probably changing rapidly,
  AND the GROUP should be strong,
  AND the STRUCTURE should be decentralized.

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[1] Also see the section on Structure for additional TASK-STRUCTURE discussion.

Task: And Information Systems

The concept of task is an integral part of any information system. Maish (1979:39) in a study concerning information system users in Washington, D.C., described the task activities facing managers as:

- improving the effectiveness of the system and the organization,
- anticipating user reactions, attitudes, and behavior, and
- reinforcing supportive user behavior or mitigating the ffects of disruptive behavior.

In another study, Bostrom (1978:164) includes task as an important socio-technical element in MIS frameworks. Beach (1976:2) also addresses the concept of the task in his model which views the characteristics of the decision task as primary determinants of the model itself. Fox and McDade (1978:155), Alter (1977:53), and Singh (1977:60) conclude individually that the recognition of the organizational tasks and their characteristics must be included in any equation posited to describe an organization.

The relationship between the organizational task(s) and information processing is explored further in the section on DSS capabilities and in Chapter V, Interviews. A definition of task requirements is needed in order to design and build an effective or efficient information system. In addition it

is important to recognize and understand (at least the information flow) how the organization task(s) and other organization variables affect one another.

Structure: Definition

The organizational structure (S in GETSIT) is the formal and informal arrangement by which information is communicated, directions are provided and authority is defined and used within a hierarchy. Included in this arrangement are assignment of task, definition of strategic and tactical goals, and management styles (Porter et al., 1975; and Perrow, 1970).

The nature of structure as an important organizational variable was studied by Amitai Etzioni (1961) in his efforts to build a topology of organizations. Etzioni suggested that the type of effective power, or structure, that is reflected in any organization is contingent on the nature of the organization and why people are there. He explained that this is the notion of a compliance structure in that it is related to the source of the manager's power means and the orientation of the individual to the organization.

The list of scholars, consultants and managers who emphasize the importance of structure and recognize its relevance to the study and understanding of organization theory is extensive. Galbraith (1974:108-121), Drucker (1974), Schein (1970), Luthans (1973), and Thompson and Vroom (1979) provide cogent arguments illustrating the need for consideration and treatment of structure as an important organization variable.

In an analysis of three general organization types, Weber (1975:15-29) concludes that in our modern societies, structure, represented by bureaucracy, is a primary and dominant feature of organizations. Leavitt (1975:72-97) explores structure as related to authority and communication networks in his laboratory studies of organizations. He suggests that characteristics of communication nets, the quantity, type and direction of information, and the nodes or connections, are basic to the structure (the converse may also be said to be true) of any organization.

An organization structure continuum, Figure IV-1, was presented by Hodgetts (1975:449). This figure implicitly depicts the change from the traditional (bureaucratic) toward more modern (adaptive) structures.

```
BUREAUCRATIC                         ADAPTIVE
          ----------------------------------->
STRUCTURES           time            STRUCTURES
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Figure IV-1. An Organization Structure Continuum (Hodgetts, 1975:449)

Organizations have been broadly defined as "intricate human strategies designed to achieve certain objectives" (Argyris, 1971: 264). There is, however, no single strategy that is appropriate to the universe of organizations because

of the large variations in terms of goals, tasks, and operational environments (Galbraith, 1973; Lawrence and Lorsch, 1976; Chandler, 1966; Hall, 1962). One component characteristic that can be employed to distinguish among different organizations is organization structure because it is concerned with the role and personnel arrangements within an organization that specify authority, coordination, and communication relationships. These arrangements link functions and physical factors to manpower requirements and availability. More simply, organization structure describes the internal system of social relations within functioning groups -- the social processes by which organizational operations actually are or should be accomplished.

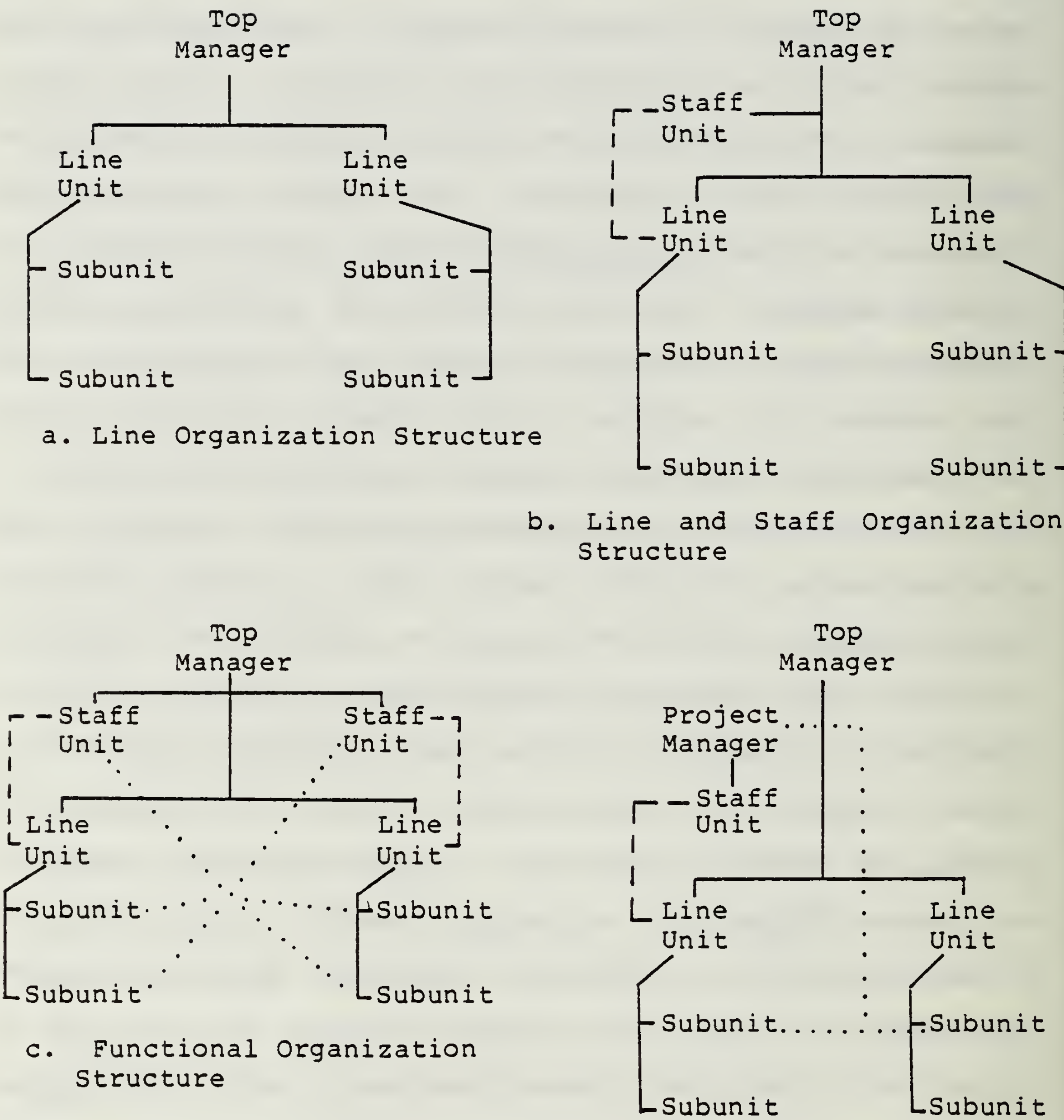
Every organization structure possesses two major elements, the formal and informal components. Formal structure is concerned with the official pattern of authority relationships and the location of responsibility and accountability in the organization. It consists of authoritative rules, regulations, and procedures that prescribe the place of each organizational member in the hierarchy: to whom they are accountable, for what they are responsible, and over whom they have authority (Blau, 1974; Bureau of Naval Personnel, 1964).

Formal structures may be defined by a particular role enumeration and hierarchical shape. One purpose of officially charting an organization is to assign specific

types of tasks to certain personnel. Each organizational member serves a particular role function. Thus, formal structure creates a division of labor within an organization to achieve group objectives. The formal structure also organizes a hierarchical configuration or differentiation in command levels. Tall or multilayered structures, having numerous levels of assigned authority and responsibility, can be created. In contrast, flat, formal structures can be developed that assign few levels of authority and control.

Active military and business usage has resulted in the identification of several basic types of formal structure, each defining different lines of command and control, advisory, and functional relationships (Spector, et al., 1976:3-3). Figure IV-2 charts these fundamental structures. Line structure emphasizes direct chains of authority and unity of command principles. Line and staff structure includes informational and advisory staff to assist and guide line or operational personnel. Functional structure arranges personnel by functional activity or type of task such as planning, logistics, communications, and intelligence functions, while project manager structure draws personnel from across departmental lines to achieve extra-or interdepartmental project or program goals; such projects are integrated and commanded by independent managers.

Lastly, matrix management is a hybrid of the project and functional structures (Thurber, 1978:17). It can provide for



a. Line Organization Structure

b. Line and Staff Organization Structure

c. Functional Organization Structure

d. Project Manager Organiization Structure

Key: ________ Line of Direct Authority
__ __ __ Line of Advisory and Information Contact
.... Line of Functional Authority

Figure IV-2. Types of Formal Organization Structures. (Spector, et al., 1974)

increased organizational responsiveness and rapid decision-making but requires a high degree of trust and confidence among managers. The primary advantage of matrix management is the capability to rapidly re-allocate resources. A disadvantage is the higher level of uncertainty that people must cope with.

The informal organization structure describes a system of dynamic, interpersonal transactions that occur in an organization. Informal processes, patterns, and relationships naturally develop among organizational personnel to help them handle the problems and requirements of their roles according to their own personal styles. While the formal structure establishes the official norms, an informal structure develops which defines the manifest activity patterns practiced, that may or may not diverge from official prescription (Blau, 1974). Depending upon the situation, the rules and procedures of formal structure may be superseded by the unique chemistry of interpersonal relations required to accomplish mission goals. Thus, informal structure identifies the reality of organizational behavior and performance.

In concept, at least five generic types of informal structure can be identified. But, in reality, as with the formal types, they are open to unlimited variation. Briefly, a centralized structure employs a focused flow of authority to a single source at the top of the organizational

hierarchy. A consultative structure also maximizes patterns of central control, but encourages vertical, upward communication of advice and guidance from the professional staff. A transactional structure stresses open communication, deliberation, and negotiation, not only vertically among hierarchical levels but laterally within levels. However, authority for the final decision may still remain with top management.

A partially delegated structure distributes authority among the professional staff while increasing the need for coordination of effort. In this structural type, the staff may possess authority to develop a set of action alternatives, but management retains the right to reject or modify these options, and thus manage by negation. Finally, a decentralized structure delegates and disperses full decision-making power to staff at lower levels of the hierarchy.

Formal and informal structures represent organizational arrangements in theory and reality, respectively. Formal structures define a set of decision methods and procedures that are designed by management to optimize organizational performance. The choice of formal structure is based on management's prior experience and expectations of the configuration of personnel that it feels will operate best given the circumstances. Thus, the decision to implement a particular formal structure is essentially a theory of

organizational optimality based on specific anticipations and assumptions. The reality of organizations can be specified by attending to the informal structure. It defines the actual decision methods and dynamic problem-solving processes that behaviorally motivate organizations.

While theory and reality -- formal and informal structure -- exist concurrently, they may not be entirely consistent with each other (Blau, 1974; Genensky and Wessel, 1964). The interpersonal dynamics that activiate an organization in performing its tasks may not necessarily conform with formal prescriptions of that process. People do not always follow official formulas, nor do they always find them most advantageous in the day-to-day exercise of their tasks. However, minor incongruities between formal and informal structures need not hinder organizational operations. On the other hand, as theory becomes further removed from reality, a restructuring of one or the other is necessary to maintain rational and effective performance.

The organization structure is identified by Tricker (1976:129) as an integral factor affecting management control. His research indicates that the professional exercise of management control requires an awareness of all aspects of the firm's structural components. Because of the number of interacting variables Tricker (1976:131) concludes that the complexity is too great to define a universally satisfactory control system. Two of the variables he

identifies are overall firm size and size of functional units.

Ein-Dor (1978:1066-1067) provides a trichotomized view of structure. He labels these as uncontrolled, partially controlled and controlled variables. Uncontrolled variables are the size of the organization, its time frame and extra-organizational situations or environment. Partially controlled variables are resources, maturity of the organization and psychological climate in the organization. finally, the controlled variables include rank and location of the responsible executive and the steering committee.

Other variables have been proposed. Table IV-1 is presented to graphically portray suggested variables associated with their proponents.

Author	Structural Variable(s), Measures(s) or Traits(s)
Ein-Dor, 1978:1067	number of product units number of profit centers number of decisions number of groups degree of system formalization level of quantification availability of decision relevant data
Pennings, 1975:401	lateral communications vertical communications participativeness power specialization social interdependence
Pennings, 1975:395	mechanistic organic centralization uncertainty complexity
Hodgetts, 1975:436	closed, stable, mechanistic open, dynamic, organic decision making process predictability of actions
Bowers and Hauser, 1977:81	decision making practices communication flow motivational conditions technological readiness
Van de Ven, 1976:67,70	differentiation and integration span of control supervisor-staff ratio administrative over-head formalization, discretion standardization, specialization division of labor

Table IV-1. Organizational Structure Characteristics.

Table IV-1 clearly shows, even from a small sample, that the component parts of structure as a concept are not totally agreed upon. In his efforts to develop a theory of organization structure context, Van de Ven (1976:65) notes

that "the complex organization consists of multiforms of structurally differentiated but independent subsystems, each with its own structural pattern for programming a cycle of activities." As an understanding of this variable is further developed the complexity of the overall framework can be appreciated.

<u>Structure: As An Organizational Variable</u>

Organization structures are composed of intricate arrangements of sub-structures all of which are interconnected with a variety of both formal and informal communication networks. The connectivity of structure with other organization variables has been the subject of numerous research efforts. For example, Tricker (1976:131) and Leavitt (1964:30-34) propose theoretical frameworks to show such interconnectedness. The variables: power and authority, environment, internal situation, climate, and management style, were noted by Tricker while Leavitt uses technology, people and task. All of these are proposed as having a high degree of interaction with one another and with the variable structure.

Van de Ven (1976:68) reviews the ongoing debate among contingency theorists concerning whether environmental characteristics, technology or the task itself determine an organization's structure. Money's research (1978:136) strongly suggests that in some situations individual and

group interactions determined the type of structure within which they exist. Woodward (1975:5671) and Jones (1978:190) provide a solid basis for considering the inter-dependency of technology and structure. A major result of their work is the suggestion that other variables be considered in a framework for organizations.

An interesting viewpoint concerning the importance and ingredients that form a structure is presented by Ross and Murdick (1975:35-42). A review of three approaches, classical, organic and behavioral, to organizational structure is followed by a consideration of the variables that constitute structure. These variables are the manager, task or work, environment and the individual. Lawrence and Lorsch (1975:43-58) present a model of organizational design that relates structure directly to the environment.

Argyris (1975:261) however, expresses the view that two important variables needed to explain organizations are the formal organizations (structures thereof), and human beings. Pugh(1975) in his introduction to Organizational Theory, defines organization theory as the study of several variables, the first of which is structure. The importance of a rich variety of interactions among variables of structure, and individuals is stressed. Structure is further depicted and explained as the interworking of authority, task allocation and communication systems.

According to French and Bell (1973:78) the structure of an organization is composed of many sub-elements, such as functional divisions, rules, communications (feed-forward and feed-back), authority, planning, coordination, control, decision making and work flow. Luthans and Kreitner (1975:80) discuss organizational structure in the sense that structure determines, to a great extent, the types of intervention strategies used by consultants. Organic, decentralized organizations suggest self-controlled interventions whereas mechanistic, centralized enterprises may be more responsive to carefully delineated and closely controlled strategies.

Perrow (1970:78) indicates that manipulation of organizational variables, including the structure, is the most practical and efficient way of dealing with organizational problems. In many cases, it is both the managerial style and organization tasks that dictate an effective structure, but it is the structural interaction that sustains the organization. Porter, Lawler and Hackman (1975:20) point out that "since formal organizations can be considered as contrived social systems, it is clear that their structures are man made and not inherently determined by a particular set of circumstances." They strongly advocate the study of structure(s) with regard to understanding the behavior of people in organizations. Suggested is the fact that often overlooked are "the ways in

which particular structures can help determine the nature of events that take place in an organization."

Structural components of organizations that have been identified as being sensitive to technological change(s) include:

authority levels,
span of control,
communication planning,
personnel selection,
manager/non-manager ratio, and
control methods.

A primary research work to date on identification of technology and structure interactions is that of Woodward (1975:56-71). Her work indicates that as the complexity of the technology increases a corresponding increase in the number of authority levels, a general decrease in direct labor costs and an increase in indirect labor costs results. Written communications also tend to increase in organizations using advanced technology which subsequently imposes a requirement for higher skill levels in report preparation and written skills. Other important structural areas impacted include a changing ratio of managers and supervisory staff, an increase in the span of control of the chief executive officer, an increase in organization flexibility (due, perhaps, to less clearly defined duties and responsibilities) and increased specialization.

The structural components that constitute procedures and practices relative to planning, communications and coordinating are highly dependent on technology. Computers, for example, provide an ability to both plan faster and further, as well as include many more variables in the planning process. Entropic considerations, or the "context factors" of feedback, interface and openness require the formulation of organization structure around the technology available for use as well as technological requirements of the environment (Porter and Lawler, 1975:222). Technology is regarded as a contributing element to the anatomical dimensions and operational factors of a given structure.

In the last ten years, technology, particularly computer technology has impacted organizational structure changes in the areas of departmental consolidation, reduction in the number of levels in the organization and a reduced span of control. The capability to collect, store and retrieve large amounts of data in a relatively short period of time and to transmit it and/or present it in a variety of ways provides new horizons for decision making. At the same time it represents a possible requirement to modify the structure of decision making and implementation, the communication thereof and follow-on control.

A high rate of technological change will demand a corresponding rate of change in the organizational structure or at least the capability to assimilate the change (Leavitt,

1973:31). Conversely, should the organization change its structure drastically, a corresponding technological redesign may be required. Organizational flexibility is an important attribute for structural design. Smaller organizations will usually have a much more difficult time than larger ones because they generally must structure themselves to be either adaptive or relatively rigid. Larger companies can accommodate correspondingly larger changes in their technological base because of their complex structures. Filley, House and Kerr (1976:299) provide data to indicate the higher levels of organizational structures are more weakly and inconsistently influenced by technology as the size of the enterprise increases.

Reflecting on previous studies, Luthans (1976:295) concludes that structural differences could not be accounted for by differences in managerial philosophies, consultant advice or trial and error. It seems that not only the form but the substance of structure is highly interrelated with technology.

The techno-structural models of organizations exemplified by the matrix, free-form, project and systems structures are attempts to maximize the interrelationships of these variables (Luthans, 1976:295). Tosi (1975:82) emphasizes the criticality and sensitivity of organization conditions to changing technology and structure flexibility while in Hornstein (1971:26-27) we find the postulate that

technological influence on organizational structure is a driving factor in selecting intervention strategies. The extensive interaction between structure and technology warrants special attention in studies concerning organizations.

Aspects of both the formal and informal structure are closely related to another variable, task. Gouldner and Trist (1954)[1] in Patterns of Industrial Bureaucracy provide an excellent example. Unpredicted consequences resulted from replacement of management structure (style and personnel) without a concomitant change in task. What happened, in part, was that structural changes dictated, at least for the plant manager, a change in the performance of certain organizational tasks, including their selection. The design of task areas should be an integral planning component when designing the structure, especially considering communication needs, interpersonal needs, and group interaction. While organizational structure may be created to control, regulate and facilitate maintenance of a desired work flow they must be consistent with work flow demands (Hornstein, 1971:158).

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[1]A.W. Gouldner described the results of a bureaucratic attempt to improve industrial efficiency without concern for specific technology, task or individual requirements. Another work appropriate for review in this area is Trist and Bamforth's article on Longwall Coal-Getting (see bibliography for full citation).

French and Bell (1973:74-79) suggest that structural task groupings are designed around work flow, work rules, authority systems (who reports to whom) procedures and practices relative to communicating, planning and coordination. Work flow in this sense is defined as discrete tasks that are performed in a particular predetermined order. These tasks and their relationships to one another are assumed to be an efficient basis to design an organization structure. Structural differentiation (viewing it as made up of different parts) is directly related to the size, number and type of organization tasks required (Blau, 1973:256-270). The larger an organization and the greater the scope of its responsibilities, the more pronounced is its differentiation. If this is the case and we accept Argyris' ideas (1975:261-278) on task specialization, then specialization of many of the tasks will improve organizational and administrative efficiency.

Porter and Lawler (1975:303-327) relate task and structure in that task elements of specialization, specification, standardization and formulation are members of the "operational features" of structural factors. In addition, direct relationships have been established between structure (height of the organizational level) and the degree of job and need satisfaction, and between the height-of-the-level and perceived necessity for an inner directed type of job behavior. In other words, with respect

to line-staff hierarchies a positive relationship between the line type of position and degree of need satisfaction has been identified. This is especially relevant in trying to understand both the task structure and on-going social processes. At the lower organization levels these seem to be influenced significantly by the type of control system (or structure) imposed. (Filley, et al., 1976:299)

It is interesting to note that the higher a member's status in an organization and the clearer the task structure, then the greater the frequency of his performance of promotive (initiation of structure) functions (Triandis, 1971:57-102). Clarity of task structure is equally important at the lower levels.

A perennial problem of industry has been that of sustaining human productivity over extended periods. The advent of the production line accentuated the problem by establishing boredom as an integral portion of the task. The human intensive production line is now being studied under the heading of job enlargement; however, the concept of job enlargement may have been drastically overstated and overgeneralized. Hulin and Blood (1973:203-214) propose that the argument for greater task responsibility as a means of motivating workers, decreasing boredom and dissatisfaction, and increasing attendance and productivity is valid only when applied to certain segments of the work force. The work

force they studied includes white collar and supervisory workers and non-alienated blue collar workers.

Formal structures are usually portrayed graphically on an organization chart. Communications problems result from over emphasis on this document because of what Scanlon (1974:263) calls positional and authority differences, interdepartmental competition, hiding behind the organization chart, and physical layout of the organization facility. An overt effort is necessary to overcome this situation by including considerations for the individual in the formal structure. As McCaskey's research (1974) indicates, the amount of ambiguity perceived by the decision maker (individual) is adjusted to reflect the individual's need for stimulation and closure. The tolerance for ambiquity varies among individual decision makers and is manifested in differing organizational structures and structural changes.

A variety of authors have tried to define and explore the interdependency of organization variables which affect structure. Table IV-2 relates these variables and authors. Of course all the interactions cannot be displayed but it is evident that a great deal of importance is placed on creating a framework for understanding the formal structure.

AUTHOR	1	2	3	4	5	6	7	8	9
Fox and McDade, 1978:154	X		X	X		X		X	
Pennings, 1975:401,394, 393	X	X	X	X	X		X	X	X
Leavitt, 1964:30	X		X	X				X	
Bedeian, 1978:142			X	X			X	X	
Bostrom, 1978:164	X		X	X				X	
Ginzberg, 1978:40	X		X	X				X	

VARIABLE

1 Technology
2 Environment
3 Task
4 Structure
5 Power
6 Goals
7 Groups
8 Individuals
9 Communication

Table IV-2. Organization Variable Interaction by Author.

These are only some of the many variables related to structure which receive attention by organization researchers. For example, Gissin (1979:7) suggests that centralization is a key issue necessary to enhance functional interoperability within and among organizations. This is a prime consideration of large military forces, multi-national firms and conglomerates. Consideration of formal organization goals and constraints and an explicit analysis of relationships between component variables in the model are necessary to conduct decision analysis (Lee, 1972:7). Once

an understanding has been obtained of the formal structural configuration and the design patterns of the other components, then the linking action of these elements may be examined (Van de Ven, 1976:67).

The informal structure is equally affected by other organization elements. Task, for example, perturbs structure a great deal. Informal organization structures vary in direct relation to the degree to which tasks are structured. Highly structured tasks have known and clear parameters, and the alternatives to resolve them belong to a set of acknowledged methods. Sufficient information is usually available to formulate solutions by choosing known or preplanned options. These tasks tend to be fairly routine and their solutions deterministic. Unstructured tasks contain somewhat ambiguous parameters. The information required to develop solutions is widely dispersed and, to a large degree, initially unknown and uncertain. Whether adequate information exists to cope with these tasks in a rational and logical fashion is questionable.

Thurber's view (1978:17-18) includes:

> IF the STRUCTURE is traditional,
> THEN the TASK should be clear and
> well defined.

and

IF the TASK is acquisition,
THEN the STRUCTURE should be matrix.

In addition Leavitt (1964:34) suggests:

IF the STRUCTURE is decentralized,
THEN increased INDIVIDUAL motivation
and goal oriented behavior results
AND increased flexibility is possible,
AND greater variation in technology is
possible.

Organizational goals are composed of sets of tasks; the degree of overall structure in these component tasks can be used to characterize overall goals. While some tasks may be highly structured, the mix of tasks may be such that the parameters of broad corporate goals are ambiguous and vague. Such goals are complex and their accomplishment is uncertain and probabilistic. Particular types of informal structure are appropriate depending on the structure of the tasks. Specifically, highly structured tasks tend to be dealt with in an efficient manner by highly centralized organizations; unstructured tasks necessitate integrated group

decision-making and thus more decentralized organization structures.

Several researchers have dealt with the impact of task structure on informal relations within organizations that have experienced technological innovation. The literature discusses this relationship in terms of two components of task structure -- task complexity and task uncertainty. Each of these dimensions will be reviewed separately. In an empirical study of 16 health and welfare agencies in a midwestern metropolis, Hage and Aiken (1972:260-262) find that the more routine the task, the more centralized the informal organization structure of the agency. Klahr and Leavitt (1967:107-139) and Whisler (1967:27-37) reach similar conclusions in separate case studies of organizations using computerized systems. They observe that repetitive, routine tasks foster centralization of operations, especially with the advent of the computer. In contrast, novel and complex tasks, which are not well-structured, seem to generate more participatory and flexible informal organization structures. In another approach to the same problem, Faucheux and MacKenzie (1967:361-375) employ an experimental situation to test the relationship between problem structure and organization structure. Their results agree with the conclusions of the studies previously cited. Routine, deductive tasks result in centralization, while nonroutine, inferential tasks do not.

To justify these results, Mohr (1971:444-459) and Myers (1967:13-15) reason that nonroutine problems, i.e. tasks, are indefinite and uncertain. Consequently, their solutions cannot be programmed or prescribed, and groups of experts must cope with each problem on an individual basis. In specialized, sophisticated, and complex goal sets, professionals must assume a high degree of responsibility for problem solution. There is a need for lateral communication among expert staff members to cope with unique problems and, thus, a decentralized or transactional structure is essential. Routine problems, on the other hand, minimize the need for professional experts and maximize the need for managerial coordination (Blau, 1974; Carlisle, 1974:9-18). These requirements lead to centralization of organization structure.

There are some dissenting opinions on the subject of task structure and organization structure. Pugh, et al. (1972:183-208) argue that routine tasks can be dealt with by decentralized processes and Buckingham (1961:77-79) concurs. As decision-making becomes more rational and the number of possible and acceptable alternatives narrows, top management may feel more confident in delegating routine tasks to lower echelons. However, the deterministic and preprogrammed nature of these routine decisions makes it questionable as to whether dynamic human choice is actually involved.

Task uncertainty, characterized by incomplete information, unknown options, and changing conditions, is the other dimension of problem structure that may also influence organization structure. Upon analyzing case studies of three firms, Galbraith (1973:142-148) concludes that the extent to which lateral relations are used in organizational decision processes varies directly with the degree of task uncertainty. His results indicate that, in the most uncertain environments, decision-making should become decentralized. Slater and Bennis (1964:51-59) cite studies that reinforce Galbraith's findings. These authors assert that, for simple tasks under conditions of uncertainty, an autocratic, centralized structure is efficient. However, when conditions are complex, changing, and uncertain, a participatory, decentralized, informal organization structure is most appropriate.

Burns (1971) and Burns and Stalker (1966:96-125) put forth two theoretical constructs, mechanistic and organismic organization structures, to explain these results. In conditions of task certainty and stability, mechanistic and highly centralized structures are well adapted because problem-solving methods, duties, and relationships can be defined precisely, thus minimizing the need for group deliberation. In contrast, organismic and decentralized structures are more efficient when conditions are uncertain and unstable because decision procedures, relationships,

functions, and data must be constantly reevaluated and no individual has a monopoly over this information. Thus, delegation of authority, increased lateral communication, and greater coordination within a decision-making group will likely provide a satisfactory organization structure when the task to be solved is uncertain.

Galbraith (1974:28) provides a view of the relationships between several variables and tasks. These are represented here in the production rule format.

IF the STRUCTURE is large,
  AND MECHANISTIC,
  AND GROUPS are numerous,
  AND specialized,
  AND multiple resources are available,
THEN multiple sub-TASKS should be created,
  AND project team decision making
    is appropriate,
  AND management linking pins are
    very important.

From this review, a clear consensus emerges on the relationship between task structure and organization structure.

Opinion is divided on the effects of high stress environments and tasks on informal organization structure.

Carlisle (1974:16) takes the position that when quick on-the-spot decisions are required, authority to make them should be delegated. Those closest to the situation have the most information and can make the most rapid and presumably accurate judgements. Stanford Research Institute (1974) suggests that decentralized informal structures are often employed in military task forces when commanders are faced with stressful and threatening stimuli. DeCarlo (1967:244-270) advocates a decentralized organization structure in times of stress. He argues that centralized structures are overly efficient and often encourage fixed and rigid responses in stressful situations. Decentralized processes, in contrast, are more adaptable and encourage innovative handling of stressful missions.

While Galbraith (1973:8-20) and Myers (1967) acknowledge the value of decentralized authority structure, they also see limits to its application. In highly stressful situations, including many military operations, a clear line of central authority would provide the most effective decision-making structure. When reaction time is of the essence, centralization ought to be implemented since it leaves decisional authority to those who possess the most responsibility.

The following production rules are developed on the basis of the preceding literature review.

IF the STRUCTURE is centralized,
OR partially delegated,
OR a decentralized informal type,
THEN highly stressful ENVIRONMENTS,
AND highly stressful TASKS are manageable.

IF the TASK is nonstressful,
OR the ENVIRONMENT is nonstressful,
OR both are nonstressful,
THEN a consultative,
OR transactional STRUCTURE is appropriate.

Structure: And Information Processing

It's important for purposes of this research to note connectivity of the proposed variable, structure, with aspects of MIS and DSS application. Again there is an abundance of literature, therefore, the following discussion represents a small sample of the population of data on the information system components which interact with or are affected by the organization structure.

The result of a decision maker's functional position in a hierarchy and relative position of authority has an effect on the degree to which new information is accepted and used (Cheney, 1978:173-174). The relative stability and complexity of the individual's organizational unit is identified as a contributing factor to the use of

information. Alter (1977:52-53) identifies a key role in the structural component as an intermediary who maintained effective communications with decision makers. However, this role is only necessary when the decision maker (DM) is not a hands-on user.

Bariff et al., (1977:822) and Bostrom (1978:164) argue that it is important to include and understand the interactions of the user, structure, technology and task for successful development and implementation of information systems. With a somewhat different perspective Olson (1978:151) identifies centralization and resource distribution issues as central to information processing. Glennon (1978:79) and Matthews (1978:86) provide support for the importance of the structural variable with respect to the effective use of information systems.

The organizational context of MIS has been largely ignored (Franz, 1978:301) however, there are movements to correct this oversight. In a table depicting important MIS research areas, Franz includes the group, individual and organization along with the structural characteristics of control and planning. Both Cheney (1978:173) and Ein-Dor (1978:1070-1075) identify the impact of several structural variables on the likelihood of success of a MIS project. These include level of management, management support and the existence of a steering committee.

Modrick (1976) provides an illustration of efforts to integrate decision aiding systems into military tactical decision making. His research results indicate the need for adaptive decision aiding systems engineered to fit specific decision making situations. Additional support to suggest how organizational variables directly affect DSS requirements is provided by Spector, Hayes, and Crain (1976). Their investigation of the impact of computer-based decision aids on a high level management staff resulted in identification of several significant relationships. In one instance (Spector et al., 1976:3-22) it was noted that the direction of communications within the organization were dependent on the informal (leader centered) staff structure. In this instance as the organization structure became less centralized, communications were less predominantly downward and more laterally directed. The DSS capabilities included in automatic message handling and distribution could be used to support this structure as the continuum of communication requirements moves from basically downward to lateral. Simon (1965:104) summarizes this perspective:

> "Organizational form ... must be joint function of the characteristics of humans and their tools and the nature of the task environment. When one or the other of these changes significantly, we may expect concurrent modifications to be required in the organizational structure -- for example, in the

amount of centralization or decentralization which is desirable."

The following rule is suggested.

IF the organization STRUCTURE is less centralized,
AND communications are laterally directed,
THEN automatic message handling and distribution systems are recommended DSS capabilities.

Hodgetts (1975:436) provides a similar observation in that:

IF ENVIRONMENT is dynamic,
AND/OR TECHNOLOGY is high,
THEN an adaptive STRUCTURE is recommended.

Discussion has also focused on the relationship between staff training, and experience and types of informal organization structure. While much of this literature is concerned with staff skills in noncomputer contexts, conclusions can be assimilated into computer-based environments. Tannenbaum and Schmidt (1958:95-101), and Carlisle (1974:15-17) conclude that delegation of authority or decentralization of informal structure is probable if

subordinates are knowledgeable and experienced in decision-making techniques. Blau (1974), in a theoretical analysis, and Slater and Bennis (1964:51-59) on the basis of empirical evidence, find that the same tendency toward decentralization occurs as workers become more professional in their approach to specific tasks and overall goals of the organization. Burns (1971) speculates that the location of knowledge and skill in an organization defines the center of authority. Thus, if subordinates are highly skilled and professional, an organismic type of organization, in which authority tends to be dispersed and decentralized, should be most appropriate.

Luthans (1976:414) views task skills and organization structure in a variety of ways.

> IF the INDIVIDUAL staff is skilled in
> technical and decision analysis methods,
> THEN consultative, transactional, partially,
> delegated or decentralized informal
> STRUCTUREs are appropriate.

> IF the INDIVIDUAL staff lack training in
> technical decision analysis skills,
> THEN a centralized STRUCTURE is appropriate
> AND outside consultants are recommended.

IF the STRUCTURE is project management
or matrix,
THEN the TECHNOLOGY is probably advanced
and complex.

In the current military environment, Stanford Research Institute (1974) observes that a commander is likely to delegate authority to the staff if he feels it is knowledgeable and experienced in the mission and the commander himself is inexperienced. However, it is also possible that, given a knowledgeable staff, a commander who is competent in all aspects of mission performance may also decentralize authority.

Researchers who have analyzed organizations in which MIS has been introduced reach conclusion similar to the studies previously cited, i.e. staff skill contributes to the appropriateness of decentralized organization structures. On the basis of several case studies and a review of relevant literature, Whisler (1967:34-37) argues that, in the long run, professionalization of workers in highly differentiated tasks may limit the degree of centralization within organizations. Forrester (1967:275-281) also concludes that MIS offers subordinates greater access to the rules and information that are the lifeblood of the organization. Staff members that are knowledgeable about organizational

operations, policies, and decision tools usually prefer participatory informal structures.

Several researchers diverge from this consensus of opinion. They predict that neither centralization nor decentralization is the most appropriate information structure in situations where subordinates are professionals skilled in technical and decision analysis methods. Rather, they argue that a transactional form of informal structure can best deal with an organization having a skilled staff. Colbert (1974) proposes that skilled staffers, who are responsible for interpreting and analyzing computer output and coordinating MIS needs across departmental lines, require a transactional structure in which information flows vertically, as well as horizontally, within the organization. While Colbert does not specify where final decision-making authority should reside in this open communication structure, the responsibility offered to professionally skilled subordinates demands an organizational form that fully integrates them into the decision-making process.

Wilkinson (1955) also prefers a transactional structure in response to high staff skill. His analysis of the Pacific Command (PACOM) ADP system emphasizes the need for active participation and integration of skilled personnel. Although both commander and staff should be effectively immersed in the decision process, the commander is not likely to delegate ultimate authority to make policy decisions, no matter how

skilled or policy conscious the staff is. Transaction structures allow for this type of decision-making arrangement. Thus, the literature strongly suggests that the presence of skilled staff members fosters an informal organization structure in which trained professionals significantly contribute to the decision-making process.

The formal structure implications of maintaining a technically skilled staff are quite apparent. If an existing staff is competent in technical decision analysis methods, the need to assign specially skilled personnel from outside the organization is greatly reduced. In a simulated air defense direction center, Chapman and Kennedy (1955) found that no auxiliary personnel were required to operate the center's systems if the subjects were given an opportunity to use their own skills. As the volume of computer usage in an organization increases, it is preferable to maintain a staff that can integrate functional and technical skills so that organizational policy directions are followed (Colbert, 1974; Federico, et al., 1975; Whisler, 1967). An unskilled staff may resist technological change and force assignment of outside experts to activate system usage (Leavitt and Whisler, 1958:41-48; Williams and Adams, 1968:44-48).

The evolution of the computer based information systems, and the new capabilities of decision support systems have had a major impact on the organization. The components of the variable known as structure have a direct relationship with

both the MIS and DSS application. Only by identifying these relationships can an effective system evolve. Ein-Dor (1978:1074) suggests:

> IF the STRUCTURE includes a high level steering committee assigned to the MIS function,
> THEN the probability of success is high.
>
> IF the STRUCTURE rank of the MIS chief is executive,
> THEN the probability of a successful MIS is near zero.

Individual: Definition

The synergistic representation of "corporate personality, strategy, and idealogical goals of top-management ... is the most important variable in shaping the company's organization," (Ross and Murdick, 1975:40). Only people (individuals, the I in GETSIT) have goals and it is only through people that organizations set and attain objectives. Organizations are shaped by the value systems and philosophies of managers.

Adapting an organization to accommodate needs of member individuals may be a method of achieving increased productivity (Luthans and Kreitner, 1975:92). The individual provides the organization with its goods and is the target of organization behavior modification and organizational development (OD) efforts. Many OD techniques begin with emphasis on training the individual. It has been the client centered work, for example, that has been successfully used to change other organizational attributes such as power structures (Leavitt, 1964:40).

It is the individual regardless of title (leader, manager, commander) who is the decision maker directly or indirectly influencing the current and future directions of any organization. Graham's research (1977:69) indicates that the success or failure of an organization will be governed by actions of individuals both internal and external to the firm. The interaction of the individual with and within an

organization is a key factor in any organization's life (Ross, 1975:40: Luthans and Kreitner, 1975:92; Porter, 1975:25-26, 128).

Another aspect of the concern for the individual in the organization is explained by Lawler (1973:207). Motivation of the individual is presented as one of the major areas of study in organization behavior. Lawler concludes that of the managerial approaches offered, paternalistic, scientific management, participative or combination, none sufficiently takes into account individual differences. In his research Lawler concludes that organizations must recognize the uniqueness of the human being and adopt individualized approaches in attempting to deal with them. The impact of the individual is amply illustrated by the outcome of the Hawthorne studies and Gouldner's description (1954) of the gypsum plant.

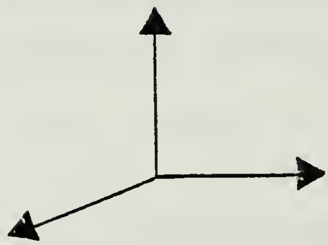
McGregor's (1960) description of Theory X and Theory Y concern the individual and his interaction with the organization. The Theory X manager, according to McGregor, does not worry about employee behavior because the worker does not care about his work. The Theory Y manager is interested and concerned. If McGregor's theory is true this type of manager should prove to be a more valuable asset to the company than the first because of his concern. A stimulus-response model is proposed by Luthans (1973:327) to describe the interaction of the environment, an organism's

perception of inputs, and resultant behavior. The actions of the individual, his productivity, and his behavior toward the task and the organization are factors that can be explained using this model.

Individual: Leadership Styles

Schein (1970:42) points out the impact of how a worker perceives the actions of a supervisor and will actually work more effectively when the feeling (cognition) is present that supervision is not pressing. He continues to stress the importance and positive influence of human interaction in task accomplishment. Management training is heavily emphasized in efforts to produce managerial skills that are more employee centered. Further importance of the concept of the individual is illustrated in Schein's discussion on the manager's assumptions about people, i.e. the concepts of rational-economic man, social man, self-actualizing man and finally, complex man.

The life of the organization depends upon the presence of human beings. Organization theory explains a system of interrelated behaviors and expectations of the members of that system. "The relationship between the individual and an organization must be regarded as an important segment of organization theory," (Thompson, 1979:23). The model, Figure IV-3, used by Thompson (1971:23) shows a relationship of the



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where

PERSONAL CHARACTERSISTICS are	1. physique, appearance 2. knowledge, skills 3. personality, values 4. reference groups 5. trade, profession 6. social status
IDENTIFICATION WITH THE ORGANIZATION is	1. position 2. role 3. work group memberships 4. other subgroup memberships 5. extraorganizational memberships

and

EXCHANGE WITH THE ORGANIZATION is	1. performances 2. interactions 3. expectations 4. reinforcements

Figure IV-3. Individual - Organization Interaction.

(Thompson, 1971:23)

individual in an organization setting. It portrays a three dimensional view of attributes that individuals experience in dealing with organizations.

Uncertainty is a condition experienced to a greater or lesser degree by all individuals. Bowers and Hauser (1977:77) found that under uncertainty the personal style of the decision maker (DM) is very important. McCaskey's findings (UCLA, 1974) indicate that the amount of ambiguity perceived by the individual is adjusted to reflect that individual's need for stimulation and closure. While the tolerance for uncertainty varies among individual decision makers it is manifested in different organizational structures and structural changes. An example is provided by Thurber (1978:20) in pointing out that as uncertainty increases individuals perceive diminished powers and prefer to avoid negotiating for resources. This is shown by the movement away from matrix style management in increasingly ambiguous circumstances.

Leadership can only be provided by the individual. The role of the leader is to iron out misunderstandings, observe developing conflicts and intervene as necessary to minimize explosive situations that threaten the organization (Singh, 1977:59). As Griffin's work (1978:118) shows, different individuals respond to different stimuli, i.e. some are satisfied with high scope tasks and others prefer routine matters.

The leader style should fit the circumstance surrounding the decision to be made and it may need to vary from authoritarian to consultative (Beggs, 1978:27). As Tricker (1976:130) concluded "The professional exercise of management control calls for an awareness of all aspects of the situation ..."

Individual decision maker attributes are very relevant. For example, Griffin (1978:119) indicates that the achievement-oriented leadership style is associated with employee motivation for greater productivity and confidence in their abilities. The participative leader behavior is similarly described. Likert (1967:4) devised a matrix of leader styles and leadership variables which is used to approximate leader styles.

Various authors have developed models to describe individual decision making behavior (Campbell,1975:2-5). The classic economic model describes an individual who maximizes economic objectives. The administrative model stress expectations while the Skinnerian model concentrates on rewards to explain choice behavior. An incremental or controlled anarchy model of decision making behavior is not based on a rational or satisfying approach, but on a complex set of factors.

Scanlon (1974:248-253) developed four similar concepts of human nature. He summarizes his work by proposing that no single theory fully describes the individual within the

organizational context. The total man concept suggests that the decision maker is complex and unique, and a match between management situations and the individual is important. Regardless of the approach adopted it is important to understand that regarding the individual as an organizational variable is well founded.

Individual: As an Organizational Variable

Considerable study has been performed by Porter, et al. (1975:25-26) concerning the importance of individual interaction within organizations. It is a practical necessity to consider the development of both individuals and organizations simultaneously. Porter, Lawler and Hackman (1975:128) present the model in Figure IV-4 and emphasize that it is explicitly cyclic and systematic in nature: the actions of the individual and of organizations continuously feedback upon and influence one another.

> "It is proposed that the degree to which organizations value and seek to perpetuate the contributions of their members varies directly with the extent to which these contributions fulfill the expectations that the organization has of the individual." Concomitantly, "the degree to which individuals value and seek to maintain memberships in organizations and involvement in organizational activities varies as a direct function of the degree to which they find that such memberhsips and involvement serve to satisfy their own personal needs or facilitate the achievement of their goals." (Porter et al., 1975:109)

This most certainly reemphasizes the importance of the simultaneous development of the individual and organization.

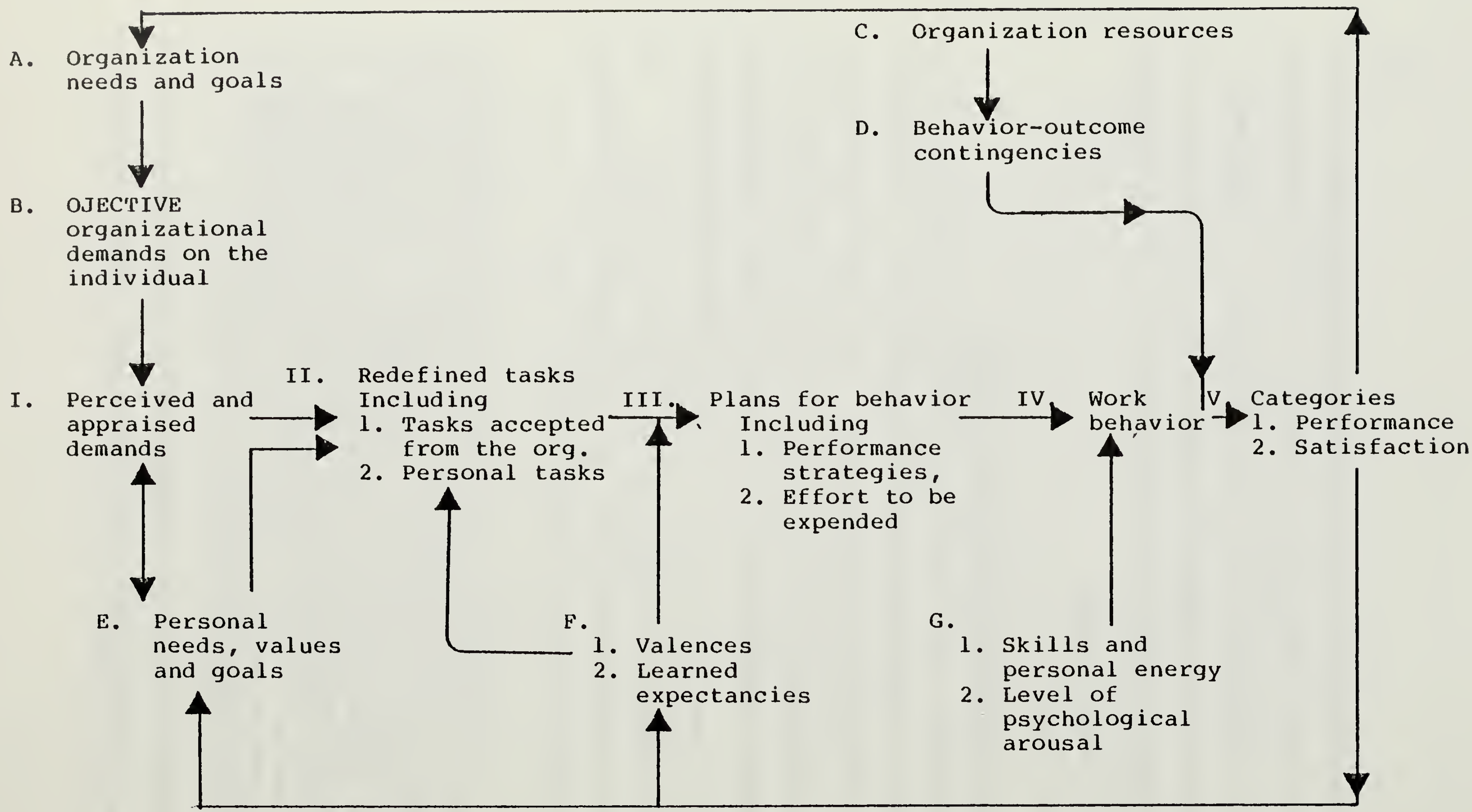

Figure IV-4. A Model of Individual Performance in Organizations

(Porter, Lawler and Hackman, 1975;121)

Argyris (1975:261) selected the formal organization and the individual as the two basic variables for a general model to understand organizational behavior in his presentation, "The Impact of the Formal Organization upon the Individual." He concludes (1975:276-277) by summarizing his work:

> "a total organization is more than the formal organization. Conceptualizing it as a behavioral system we may conclude that an organization is a composite of four different but interrelated subsystems resulting in the following kinds of behavior.
>
> a. The behavior that results from each individual's attempt to fulfill his idiosyncratic needs,
>
> b. the behavior that results from the formal organizational demands,
>
> c. the behavior that results from the demands of the informal activities, and
>
> d. the behavior that is a resultant of the unique patterning for each organization of the three levels above."

The requirements for decisions to be made is a result of complex interaction among many variables. Leifer and Loehr (1978:132) have suggested conducting experiments with individual decision makers to explore these interrelationships. While this suggestion is valid from the research perspective it is generally unrealizable from the availability standpoint of busy managers.

Reasonable alternatives include modeling; however, identification of and agreement on common factors is often difficult (Comte, 1978:278). Whallon (1978:157) studies decision maker uncertainty as a psychological state resulting

from the manager's perception of the environment while Nackel et al. (1978:1266) reports on leader development of influence and power. The report findings include the facts that the consensus process performs well in environments where the decision makers have equal influence and power. Another conclusion is that where the leader brings out the appropriate information and coordinates the group, better decisions are likely to evolve.

Other individual-group interdependencies were noted by Scanlon (1974:274) in his identification of factors which influence group cohesiveness. In one particular case he notes that the more dependent the individual is on the group the greater the attractiveness the group will have for that person. As discussed earlier this promotes group cohesiveness.

The effect of the organization structure was also explored by Scanlon (1974:273). His results show how the structural attributes of positional authority differences, interdepartmental competition and even physical layout provide individuals with communication barriers. Further research conducted by Money and Duncan (1978:136-138) indicates that conflict between individuals and groups is related to the organizational structure.

Researchers have studied the individual as one variable in a larger system. Lee and Moore (1975:480-481) include the individual (owners, employees, customers and dealers) as a

member of their overall discussion of organization objectives, goals and policies. The formal and informal organization structure, and environmental conditions are also included. Leavitt (1964:30-44) concludes that changes in the individual usually have an impact on any or all of the three variables technology, task and structure. For example, he finds that it was only through people, singularly and in groups, that tasks are accomplished.

Bedeian et al. (1978:142) explores relationships between personal (INDIVIDUAL), job-related tasks (TASK), interpersonal (GROUP) activities and the organizational climate (STRUCTURE). A high degree of interactivicty is reported. Similar interactivity is noted by Ginzberg (1978:41-48). The decision maker's role is seen as one which has to be flexible enough to accommodate the task at hand and consciously recognize the decision-making environment. In addition, Ginzberg recognizes that a change in technology can require subsequent changes in task, structure or individual. However, there are no suggestions as to what kind of changes are needed which is an argument for continued research.

Viewing organizations as socio-technical systems, Fox and McDade (1978:154-155) include the interrelationships among technical tasks, structural processes, goal values, people, and managerial control structure as key components of a transformation process. Slocum's model (1978:124-125) included the individual, task, technology, group and

structure, while Beach et al. (1976:39) uses individual, task and environment.

The following variables have been shown to have an impact on individual (leader) effectiveness in organizations (Filley and House, 1969:409).

> history of the organization,
>
> task requirements of the work group,
>
> psychological climate of group being led,
>
> group size,
>
> kind of job leader holds,
>
> cultural expectations of subordinates,
>
> group member personalities,
>
> community in which organization operates, and
> time required and allowed for decision making.

Hodgetts (1975:436) and Ein-Dor (1978:1067) locate the individual within specific structural situations. Hodgetts indicates objective setting activity is modified from a top down method to a broad participative mode as the structure moves from a rather closed or mechanistic form to a very open one. In the second instance, Ein-Dor relates how the rank and location of the individual is dependent on the number of levels below the chief executive officer and the location of the specific functional unit.

Association between the task requirement, group goal setting and the individual has received considerabale attention. For example, Loveland and Wall (1978:127) suggest

that goal (task) specificity and difficulty are two key elements in reducing decision making ambiguity. Beach and Mitchell (1976:1) and Griffin (1978:119) allude to the fact that task accomplishment is a major goal of individuals. Achievement of this objective is the fundamental problem of the decision-making process. Usually more than one alternative exists to attain goals; it is the job of the decision-maker to choose among several action alternatives. Leaders may prefer particular options because they comply with organizational norms or activate personal or organizational values that are relevant to the task at hand (such as limiting equipment damage and loss of life or facilitating team morale). In certain circumstances, preferences among various actions may appear clear-cut and unambiguous to a leader. However, under other conditions, the available options may fail to evoke a definitive preference.

Dominant task objectives can influence the choice of an appropriate organizational structure. A leader with a clear conception of his goal orientation is likely to prefer a centralized structure; one who is ambivalent concerning task goals will probably consider participatory structures.

According to DeCarlo (1967:255), the highest priority of a leader is "the stability and long-term health of the organization ..." This places the ultimate responsibility for success of a task at the top of the organizational

hierarchy. When leaders possess clear goal preferences, they tend to create a centralized informal structure and impose their decisions and methods of operation on subordinates. This is especially the case when a leader feels that subordinates cannot be trusted to pursue a solution in line with confirmed organizational goals, or when the information, expertise, or ability of lower level staff member is questionable (Vroom and Yetton, 1973; Tannenbaum and Schmidt, 1958:95-101).

A considerable amount of literature suggests that the relationship between leader preferences and structure is mediated by organizational size. In small organizations, there is high level interface between professional personnel and the leader; negotiations, discussions, and consultations are the usual methods of interaction (Blau, 1974). In such an environment, if the leader has no particular goal preference, the group is usually capable of determining an appropriate policy direction for the organization and then participate collectively to achieve these goals. This suggests the choice of a transactional or decentralized informal structure. If the leader has a particular goal preference, on the other hand, it is likely to be known by all members of the group. This collective knowledge may encourage highly efficient group action to achieve the objectives chosen by the leader. Extensive group deliberation may be unnecessary. As a result, centralized

informal structures become increasingly appropriate when the leader provides staff members with general policy goals which they must achieve.

Leaders (individuals) often prefer particular types of leadership behavior or possess personality traits that motivate them toward certain styles of interaction with subordinates. If a leader feels comfortable with a certain behavioral style, he is likely to choose a decision method or informal structure that is congruent with this style. However, a leader's desires may not yield the most satisfactory structures or outcomes for the organization. While leader style alone has an important impact on the choice of informal structure, its effect is mediated by other situational factors.

Fiedler (1965,1967) conducted an extensive amount of research in this area. He views leadership style as a personal approach to managing, coordinating, and motivating group members toward achieving organizational objectives. Style can be equated with leadership preferences or personality. He classifies style into two categories that are simple but convenient to handle. One style emphasizes the task to be performed. The leader is authoritarian and highly directive, telling subordinates what to do and how to do it. This constitutes the traditional leadership approach in which the leader plays a controlling, active, and structured role vis-a-vis the staff. The other style of

leadership is a nondirective, group-centered approach. Behaving in an egalitarian, permissive, and passive fashion, the leader is motivated by feelings of consideration and trust for subordinates and a desire to involve them in organizational tasks. Fiedler labeled the former style task-oriented and the latter style relations-oriented.

Having defined these two leadership personalities, Fiedler attempts to analyze the conditions under which they yield effective organizational task performance. His basic premise is that different situations require different leadership styles, and he attempts to map out precisely the environment configurations upon which leadership effectiveness is contingent. After extensive testing and observation, he concludes that leadership effectiveness depends upon the relationship between leader style and the degree to which three climatic factors -- task structure, leader-member relations, and leadership position power -- enable the leader to exert influence.

Task-oriented leadership styles are most effective under the following favorable conditions: the leader has power, the informal backing of group members, and a relatively well-structured task to perform. Task-oriented leaders are also effective in relatively unfavorable situations in which the leader is not well accepted, does not have sanctions available to enforce commands, and does not possess a clear and definite task to accomplish. A leader who is permissive,

considerate, and primarily concerned with interpersonal relations within the staff will be effective in moderately favorable organizational situations, in which the leader is accepted as legitimate, the power position is minimal, and the task is unstructured. Thus, Fiedler finds a curvilinear relationship between effective leadership style and the configuration of environmental factors in organizations. His results imply that management can ensure effective organizational leadership by actively "engineering" the situation to suit a leader's personality or style.

Fiedler's research, while related, is not directly concerned with organization structure. However, his dichotomy of task-oriented and relations-oriented leadership styles can be employed to account for leadership preferences which strongly influence the choice of informal and formal organization structures. The following IF CONDITION-->THEN ACTION (production rule) statements illustrate support other authors provide.

IF the INDIVIDUAL decision maker is
  optimistic,
THEN maximin (maximize the smallest payoff)
  regret matrix (minimize regret), and
  minimax (minimize the difference between the
  best possible payoff and the one actually
  received) models should all be considered.

(Bowers and Hauser 1977:77)

IF the INDIVIDUAL project leader is faced with
  dynamic and ill structured TASKS,
  AND the INDIVIDUAL is unskilled in group
    decision processes,
THEN participative decision-making is not
  recommended.

(Biggs, 1978:21)

IF the INDIVIDUAL wants to concentrate on important issues,
AND better cope with increasing scale and complexity of a changing organization,
OR the INDIVIDUAL needs to more closely monitor and measure performance throughout the organization and have quicker, more responsive control,
THEN a decentralized STRUCTURE is recommended.
(Tricker, 1976:132)

IF the INDIVIDUAL is dependent on the GROUP,
THEN the greater GROUP cohesiveness is perceived and more stable the group becomes.
(Scanlon, 1974:274)

The important impact of leader personality and style on informal organization structure is widely recognized. Simon (1965:104) states that "organization form...must be a joint function of the characteristic of humans and their tools and the nature of the task environment." If any of these components change significantly one should expect modification in the organization structure. Several authors recognize that leader personality may influence the degree of acceptance of technological innovation and thus impact upon structural adaptability. Highly loyal, conformist, and

bureaucratic managers are likely to resist computerization of tasks because it alters secure, ongoing procedures and operations. Adaptable and open managers, on the other hand, tend to accept change in their organizations (Rose, 1969). In a similar vein, Phillips (1970) reviews an empirical study concluding that the personality attributes of workers determine their acceptance of computer methods. Burns (1971) argues that introducing computers to assist in task performance may be perceived by managers as threatening to security and advancement in the organization. Such perceived threats may cause resistance to the use of such decision aids, and ridigity in the interaction patterns within the organization. Thus, leadership personality may result in maintaining inappropriate, as well as developing new, flexible, informal organization structures.

> IF the INDIVIDUAL leader has clear task goals,
> THEN centralized, consultative, or partially delegated informal STRUCTURES are appropriate.

> IF the INDIVIDUAL leader has ambiguous TASK goals,
> THEN informal STRUCTURES of transactional or decentralized styles are appropriate.

Some researchers emphasize the effect of leadership style on informal structure, but they fail to specify the precise nature of the relationship. Myers (1967) and Harris and Erdman (1967) conclude, from reviews of the literature, that it is the personality and personal preferences of top management that influence the nature of the prevailing informal structure. Empirical tests have indicated that differences in leadership preferences cause variance in the degree to which particpative informal structures are chosen (Vroom and Yetton, 1973).

The general impact of personality on informal structure has also been documented. Thompson (1962:16) describes a military command headquarters as "the alter ego of the commander." It is the personality of the commander, coupled with the interpersonal relationships among staff officers, that determines the decision method adopted. For instance, the stronger the sense of trust and confidence a naval task force commander has in the abilities of subordinates, that is, the more intense his relations-oriented style, the more likely it is that he will choose to delegate authority to them, creating a decentralized structure (Stanford Research Institute, 1974). From this discussion, we might infer that relations-oriented leaders should favor structures at the decentralized end of the continuuum since such organizations stress increased subordinate participation and involvement. leaders with task-oriented styles, who desire to exercise

control over their environments, are likely to choose structures at the centralized end of the continuum.

> IF the INDIVIDUAL leader has a relations oriented style,
> THEN transactional, partially delegated, or decentralized informal STRUCTURES may be preferred,
> AND divisional versus pyramidal formal STRUCTURES are preferable,
> AND training of the existing staff may be preferred,
> AND placement of technical experts in a support status will evolve (.8).

Leadership style is another important determining factor of formal structure. While most researchers acknowledge this relationship, few deal directly with it. However, some inferences can be drawn from their discussions. Rose (1969) distinguishes between two managerial personality types that can be loosely related to task- and relations-oriented leadership styles. Relations-oriented managers trust their subordinates and are comfortable in the presence of information processing specialists; thus, divisional computer installations are usually preferred by these types of managers. Task-oriented leaders, on the other hand, may

resist placing a system outside their direct control and, thus, may favor pyramidal installations.

Relations-oriented managers also seem to prefer training existing staff in technical and decision analysis methods (Buckingham, 1961:71-72; Tannenbaum and Schmidt, 1958:95-101). Human relations become most important when a technological system is implemented that results in a great deal of change. Participation by existing personnel in the technological changeover and technical training is encouraged by relations-oriented leaders to build a sense of common purpose among staff members. Morale would be badly damaged if outside specialists were assigned without first consulting present staff.

The placement of decision aid operators in the formal structure is largely determined by the leaders' personal desires. It is reasonable to assume that relations-oriented leaders would wish to treat decision aid operators on an equal basis with existing personnel, but not at the expense of existing rapport. Existing functional staff may feel threatened by the technical expertise of operators if they are assigned from outside the organization. Relations-oriented managers may attempt to alleviate potential intrastaff conflicts by providing operators with lowered status in the hierarchical structure and placing them within a support unit that assists an existing functional staff.

Individual: And Information Processing

The importance of the individual with respect to information systems has been recognized. Lucas (1978:52) explicitly recognizes that the design and use of a MIS is totally under control of the organization's managers. Conditions such as staff attitudes, user attitudes and technical support are all based on the involvement of one or more individuals. Kryt (1978:115) in discussing the absolute need for the individual's involvement with MIS suggested that "the ultimate reason for whatever we do with computers is the needs of the end-users." A main element of the socio-technical framework is the individual (Bostrom, 1978:164). Designing, implementing or evaluating any DSS would be pointless if the individual were not considered.

Decision makers faced with the responsibility for information systems experience substantial uncertainty (Matthews, 1978:86). Changes in hardware, software, organization, and personnel impede the otherwise manageable activity. Whallen (1978:157) suggests this uncertainty is a psychological state resulting from the individual's perception of the environment. Factors identified as contributing to the situation are decision difficulty, information uncertainty, unknown costs, control predictions, timeliness of feedback and conflicting internal and external influences.

Leadership style may be strongly affected by the availability and use of MIS. However, a few authors take the position that introducing MIS will frustrate task-oriented leaders because it lowers the feasibility of an autocratic, centralized organization structure. According to Michael (1966) and Buckingham (1961:61-68), leaders in computer-assisted settings need to be flexible, imaginative, and capable of thinking logically and analytically. As a result, Wermuth (1972) predicts that naval commanders,i.e. decision makers, will have to become more relations-oriented and informal structures more participatory. DeCarlo (1967:262-267) adds that since leaders will be directing more technically competent people as computers become widespread, they will have to permit decentralized decision-making so as not to squelch creative and innovative opinion. Lawson (1978) points out that:

IF the decision-making INDIVIDUAL has a
TASK oriented style,
THEN a centralized or consultative
informal STRUCTURE will be preferred,
AND a pyramidal formal STRUCTURE is
recommended,
AND placement of technical experts may
be placed in a new organizational
function of equal status with other
functions.

In addition, the literature indicates that leader goal clarity in large organizations may result in a variety of possible informal structures. Even if the leader has a clear preference, communications difficulties may reduce subordinate comprehension of overall organizational policy. As a result, suboptimal, localized goals, developed by subunits of large organizations, may contradict broader policy preferences. To rectify this problem and bring organizational operations in line with leader preference, a recentralization of structure using computers may be chosen (Leavitt and Whisler, 1958:41-48; Sollenberger, 1968; Burck, 1965). A computer-based MIS, for example, offers top management a vehicle to synthesize large amounts of information about diverse organizational divisions and communicate orders to subordinates. This technology enables

recentralization of informal structure and the capability to regain control and authority over organizational direction and operations.

On the other hand, the computer can provide organizational subunits with access to data concerning not only their own operations but those of the entire organization. Thus, decisions that are made on a local basis need not be ignorant of broad management preferences and goals (Carroll, 1967:161-163). Hence, partially delegated structures are possibilities when leaders have clear goals and management information systems are available. Other researchers argue that, with the advent of MIS, managers in large organizations can benefit from rapid feedback of subordinate actions, especially in instances where leaders have a clear goal preference. The ability to monitor behavior of lower echelons accurately enables management to intervene when policy directions are not properly followed (Dearden, 1967). Thus, executive monitoring of delegated informal structures is facilitated by the computer and enables maintenance of partially delegated organizational dynamics.

In addition to executive monitoring and organizational maintenance, Franz (1978:301) suggests continued need for research in user design problems and information characteristics. He further emphasizes investigation of the behavioral and organizational components of MISs.

A variety of information systems have been identified as existing in organizations (Alter, 1977:52-53). These range from individual, user-designed file-drawer systems to highly sophisticated models implemented by consultants. This variation supports King's theories (1978:27-30) that the sophistication of managers is directly related to their use of computers, models and interactive systems. Lee (1972:9) proposes the use of modern decision analysis (DA) as a "useful tool to help the troubled decision maker." Decision analytic techniques could assist in the areas of identifying optimum choice and understanding environmental complexity.

The adequacy of an individual leader's skill in using advanced decision aiding systems varies greatly. Robey (1978:170) examines relationships between user attitudes and their actual use of a MIS. Acceptance and experience are identified as two factors that are directly related to use of the MIS. It appears that the ability to interpret output and formulate high quality decisions, either alone or with minimal consultation, widens the scope of the leader's active data base and the ability to analyze and manipulate it to his advantage. The greater the extent to which he can exercise the options of the system and interpret its results, the less filtered and biased his perspective on a problem will be and the less dependent he will be on his staff. A leader who is knowledgeable in these respects can at least communicate with the staff on a highly analytical level, reducing the

information loss and inaccuracies caused by the need for nontechnical translations. Moreover, expertise in using MIS technology enables a leader to gain access to a broad and integrated picture of the environment.

Technological expertise and the increased access to information that results are power resources which enable leaders to develop independent preferences for particular courses of action and then choose among alternatives. The degree to which leaders possess these skills depends largely upon training in technical and decision analysis methods.

Many authors recommend that leaders be fully trained in the use of computer-based decision aids, but they fail to indicate how skilled leadership will affect the organization structure. In order to maintain real control over their areas of responsibility, managers must be educated continually in the newest decision techniques (Michael, 1966; Buckingham, 1961:61-72). Colbert (1974) adds that leader proficiency in decision aid skills is the only way management can maintain an active role in the problem-solving process. In fact, in a case study of automation in an engineering plant, Emery and Marek (1966) find a decreased demand for substantive mangerial skills and increased demand for technical skills.

IF the decision-making INDIVIDUAL has a common objective function and centralized information,

THEN DSS capabilities including classical decision theory and stochastic optimal control techniques are relevant.

Several researchers point out that implementing a computer-based MIS is successful and least resisted if there is sincere commitment and involvement by top level organization leaders (Delehanty, 1967:85-95; Coleman and Riley; 1973:13-19; Beckett, 1967:232-235; Kanter, 1972:211-217). Leader commitment and enthusiasm, in turn, depend upon leader training and experience. These can be accomplished, in part, by directly involving operational management in the design of the system (Thurston, 1962:135-139, Federico, et al., 1975). Stewart (1972) tested this proposition in an empirical study and found it to be supported. Other studies dealing specifically with implementing MIS in military contexts recommend that proper implementation of these tools demands both leader and staff training in decision analysis and software skills to ensure optimal employment (Chapman and Kennedy, 1955, Genesky and Wessel, 1964).

Dickson (1978:14) provides the following observations:

IF the INDIVIDUAL is chief executive of a complex organization, e.g. President of U.S.,

THEN assistance by a highly trained technical staff is appropriate.

IF INDIVIDUAL planning is from 2 to 5 years,

OR IF the INDIVIDUAL wants to develop "most likely plans",

THEN need for computer models is high.

IF the INDIVIDUAL experiences the need for drastic, large, timely or accurate plan revisions,

THEN computer support is highly recommended.

Despite the acknowledged importance of leader training and skill in decision analysis methods, evidence is sketchy concerning their relationship with appropriate types of informal organization structure. In a theoretical study of noncomputerized industrial organizations, Burns (1971) concludes that one characteristic of mechanistic, centralized structures is the location of knowledge and skills at the top of the structural hierarchy. On the basis of case studies of 13 industrial plants, Bright (1958) found that centralized control, facilitated by the overall skills and expertise of foremen, enabled functions to be integrated rather than

departmentalized. Carlisle (1974:9-18) and Vroom and Yetton (1973) summarize this school of thought by concluding that if top level officials possess more knowledge and experience than lower level subordinates, centralization of informal structure is a likely outcome.

A somewhat different conclusion is reached by Moan (1973:7-23) as he looks at the effects of the computer on inventory control in five major companies. He finds that the technical expertise of top management is the most important variable in causing organizational change to occur in the direction of "management by exception." This means that the location of methodological skills at the top of the organizational hierarchy leads neither to complete centralization nor complete decentralization. Rather, it leads to a situation in which those in control establish limits and tolerances within which lower echelons must operate. When a problem fails to be covered by formal prescription, it is sent up the hierarchical ladder to top management for resolution.

The predominant effect of leader skill on informal organization structure can be stated as the following production rules.

IF the INDIVIDUAL is skilled in technical and decision analysis methods,

THEN centralized informal STRUCTURES are appropriate.

IF the INDIVIDUAL lacks technical and decision analysis skills,

THEN consultative, transactional, partially delegated, or decentralized informal STRUCTURE are all appropriate.

Leadership skills in decision analysis methods also affect aspects of formal organization structure. A report written by the U.S. Army Material Command (AMC) Board (1965) speculates that enlightened commanding officers will favor pyramidal computer installations to facilitate handling of computing services for various functional divisions below them. Historically, divisional installations emerged in those functional directorates of the AMC that were the principal consumers of ADP services. However, as computer programs were developed to assist many different functional areas within the AMC and commanders learned more about computer operations, pyramidal and focused ADP installations became more acceptable and cost efficient.

On the basis of his observations in corporate settings, DeCarlo (1967) essentially agrees with this conclusion. As

the analytical capabilities of top managers increase, the organization's speed of response will also increase if the computer installation is under the direct control of top management. However, DeCarlo speculates that organizations of the future will evolve into "purpose-centered units," causing pyramidal installations to become obsolete. He feels that divisional computer installations, which operate at the best of functional and task-oriented subgroups within an organization, will become prominent and overtake pyramidal structures.

The available research literature on computer installations offers the following assumption.

> IF the INDIVIDUAL is skilled in technical and decision analysis methods,
> THEN a formal pyramidal STRUCTURE is appropriate.

Skilled leaders demand that their professional staffs be trained, rather than employing specially skilled personnel from outside the organization. In a large corporation, Williams and Adams (1968:44-48) find that skilled top management insists that staffs undergo extensive technical training (a broad conceptual education in information processing and 1-2 years of programming) to assure the success of planned computer implementations. Moan

(1973:7-23) reaches a similar conclusion but argues that technically competent managers require technically skilled staffs to make "management by exception" feasible. Delegation of authority is possible when top management is confident in the abilities of subordinates to make most decisions alone.

If top management is not skilled in decision analysis techniques, specially skilled personnel are probably required (Colbert, 1974). However, because these personnel are assigned from outside the organization, management must provide them with specific policy guidelines on organizational goals or risk losing control over the organization. Thus, Colbert concludes that leaders in computer-based environments should obtain the requisite skills to deal effectively with technical problems and operations. Federico, et al. (1975) cite a 1970 survey by R. S. Jackson that counters Colbert's claims. They find that, as organizations become more technologically sophisticated, the skill requirements for leaders will decrease! As a result, top management encourages substantive experts already in the organization to develop analytical skills so that they can interpret, analyze, and transmit information back to the upper echelons. The following rule may be postulated.

IF the INDIVIDUAL leader is highly skilled,
THEN they will prefer training the existing staff,
AND external consultants will not be needed.

Various other studies have been conducted in efforts to determine causes of individual user acceptance of information systems. Cheney (1978:173-174) investigated the decision maker's environment and noted these characteristics which could affect use of the IS.

Age.
Educational level.
Years of experience.
Years in present position.
Intelligence.
Cognitive style, e.e. heuristic vs. analytic.
Managerial style.

No conclusive evidence is at hand as to the degree or in what manner these variables affect the use of ISs. However, corollary research is attempting to identify similar variables related with the resistance to MIS efforts. Dickson and Simmons (1970:168) note how various behavioral considerations, i.e. feeling of insecurity, are revealed as probable causes for resisting MIS efforts. Data are collected on all levels from operating (nonclerical) to top management. All too often, according to Glennon (1978:78-82)

commensurate assignment of authority does not accompany the designated responsibility resulting in system or project failures.

Individual change is almost always a requirement in the development and use of MISs. However, to as great a degree a possible this development and subsequent implementation must explicitly involve consideration of the psychological disposition of the system user (Bariff, 1977:882). Two sets of user behavioral variables which Bariff identifies as relevant to MIS application are cognitive style and implementation apprehension. The importance of these and other attributes of the individuals involved is also emphasized by Ginzberg's research (1978:40-41). Not only will the successful implementation often require changes in the user's view of their job, newer technologies require a far greater degree of individual change than did earlier transactional processing systems.

It is very difficult to measure how effectively a MIS is being used. Many evaluations of computer based information systems measure the technical aspects of system efficiency and operational performance rather than actual use made of the MIS and its total effectiveness. Maish (1978:39-47) in a survey of four Federal agencies notes an association between the individual's positive feelings about the MIS and involvement in its design. His conclusion is that the "research underscores the importance of having management

view computer-based information system efforts as a human relation venture, of acquiring a staff that is competent and sensitive to the user's needs and problems, and of making it clear that management is enthusiastic about, and in support of, the information system."

In any organization skilled members are a valuable asset in maximizing organizational performance. Employing information systems and decision aids to the fullest depends upon the knowledge, training, and experience of the leader, the professional staff, or specially skilled personnel who are assigned expressly for their methodological skills. Intuitively, it seems preferable that the existing professional staff possess technical and decision analysis skills so that the substantive and technical aspects of decision-making can be combined in the same individual staff members. The assignment of outside specialists may infuse sufficient methodological sophistication, but may result in naivete in matters of functional importance to an organization. Moreover, a skilled professional group, with its knowledge and understanding of organizational policy, could ably assist in skilled or unskilled leader in interpreting decision aid output and choosing among action alternatives.

This variable can be treated in a rather absolute manner for the sake of simplicity; either the entire staff possess sufficient technical skills or none at all. It is possible,

of course, that only certain staff members have the necessary skills. While this question is not analyzed here, it emphasizes the need to study the issue of decision analysis training -- who should be trained, to what extent, and how should the training be accomplished. For example, possessing technical decision analysis skills in an organization vitally influences the choice of informal and formal structures that is most appropriate. The type of organization structure that is feasible is dependent on the combination of staff and leader skills.

As was the case with leader skills, staff technological expertise has been discussed from various perspectives. Several authors (Williams and Adams, 1968:44-48; Huse, 1967:282-302; Buckingham, 1961;60-80) address the question of whether a professional staff should be actively included in designing decision aids. They unanimously conclude that staff involvement is preferable to ease the changeover to computer-based techniques and reduce the possibility of resistance. In addition, such participation is likely to increase staff cognizance of the new system's potential and thus it helps to develop the staff's skills.

Technology: Definition

Technology as defined by French and Bell (1978:78) includes the tools, machines, methods and knowledge used, or available to be used to accomplish some task. Schein (1970:108-109) defines the technological environment as the state of knowledge and instrumentation available to a system to perform its task. Slocum and Sims (1978:124) conceptualize technology as techniques used by an organization or individual to transform inputs into outputs. Providing an elaboration on this Pennings (1975:394) lists the following as attributes of technology:

equipment,
automation,
problem solving methods,
operations required to bring change to objects,
logic analysis,
development of action plans, and
contingency planning methods.

His view of technology is similar to Slocum and Sims in that all organizational products (outputs) are the result of the application of some technology.

While not providing a definition, Hodgetts (1975:423), suggests that technology consists of two components: knowledge and technique. It is the human's ability to apply the knowledge using particular techniques. He also presents

a chronological illustration which is also used here as Figure IV-5 as a historical perspective of technology.

ERA	EXAMPLE
HANDICRAFT TECHNOLOGY	CRAFTSMEN WHO PRODUCED GOODS BY HAND. COBBLERS, TAILORS, CARPENTERS.
MECHANIZED TECHNOLOGY	POWER DRIVEN MACHINERY. FACTORY SYSTEMS STARTED. FLYING SHUTTLE, STEAM ENGINE, COTTON GIN.
MECHANISTIC TECHNOLOGY	ASSEMBLY LINES. STANDARDIZED, INTERCHANGEABLE PARTS.
AUTOMATED TECHNOLOGY (2ND INDUSTRIAL REVOLUTION)	COMPUTERS. LINKED ASSEMBLY LINES. ROBOTS. AUTOMATED SYSTEMS.
CYBERNETED TECHNOLOGY	AUTOMATIC FEEDBACK AND CONTROL. CONTROL OF MACHINES BY MACHINES.

Figure IV-5. Historical Perspective of Technology.

(Hodgetts, 1975:423)

Technology: As An Organizational Variable

As the sixth of six GETSIT variables, technology has already received considerable attention in the preceding sections. However, for completeness and to permit this section the same independence as others, technology will be similarly treated.

From Penning's work (1975:393-406) on a structural-contingency model where structural and environmental uncertainty are studied, a definite relationship between the environment, organization structure and technology is noted. One implication drawn is that for a

given environment and a particular organization structure particular technologies are appropriate.

A comparison of the characteristics of the mechanistic and organic organization structures which included technologic elements is provided by Hodgetts (1975:436). The technical system consists of knowledge, time perspective and interdependency of tasks. These range from highly specialized, short term, and low in the mechanistic view to highly generalized, long term, and highly organic in the organic viewpoint. Hodgetts' work suggests the following rule.

IF TECHNOLOGY is high,
AND the sytem is dynamic,
THEN an adaptive organization STRUCTURE is recommended.

According to Tricker (1976:130) the "basic technology of an enterprise is an important variable in determining management practices." He suggests that technology, along with the labor force, management capabilities, corporate assets and customers actually comprise the environment of the organization. Shin (1978:233) includes technology as a readily evident and measurable element of the environment while Van de Ven (1976:68) reports an on-going debate of the impact of technology on organization structure.

Technology may be viewed as a vehicle to effect change in other organization variables. Ginzberg (1978:41) suggests, for example, that a change in managerial technology can result in required changes in the task, structure or personnel (individual) of the organization. Extending this work Slocum and Sims (1978:124-26) provide research indicating how job design implementations also change elements of technology. The relationships include both individual and group interactions as well as needs for redefined task requirements.

The rapidity of technological growth has demanded a continual need for task redefinition and redesign. Leavitt (1964:31) shows that a change in technology in many instances directly affects many kinds and numbers of tasks. New technologies also effect changes in structure, task and individuals. Robey (1978:170) provides a specific example relating how new technology resulted in changed attitudes of the users (individuals) which further resulted in changed work rules. Woodward (1975) notes:

> IF the TECHNOLOGY complexity increases,
> THEN the information interactions increase,
> AND the STRUCTURE increases the number of authority levels.

while Pennings concludes:

IF the ENVIRONMENT is uncertain,
THEN the TECHNOLOGY will be uncertain.

(Pennings, 1975:394)

The task characteristics that may be changed due to technological demand include; task demands (skills, knowledge, and creative ability), task difficulty, and the degree to which the task is specific or vague in prescribing behavior necessary for its completion (Hornstein, 1971:158). Examples are numerous. In the area of agriculture, for instance, new machinery, fertilizers, pesticides, crops and livestock strains, and scientific farming methods require a changing task structure. In industry, tasks are changed to accommodate such factors as numeric control in machine operations, cybernation for instruments and automatic controls, power production techniques, and automatic steel mills.

The world of mass information created by communication technology not only broadens the scope of managerial action but created many tasks and functions. These examples support French and Bell's premise (1973:78) that the actual tasks to be accomplished are highly dependent on the technological sub-system, e.g. the kinds of mechanization and tools available will extensively influence the tasks to be performed. Tosi (1975:82) concludes that technology, along

with its concomitant increase in the number and type of specialists, is generally absorbed into the organization from external sources. As this specialization increases then the technology to a large degree determines the extent that a job may be programmed. The extent and technique to which it actually is programmed should include consideration of the human who interfaces with that particular task. The operational features of structure, that is, the task elements of specialization, specification, standardization, and formalization, are very closely related to the context factor of technology available (Porter, et al., 1975:223).

Bennis (1973:327-338) proposes that future tasks will be more technical, more complicated and less programmable because of advanced technology. Intellectual prowess and cognitive processes will be relied upon in lieu of muscle power. Tasks may become far too complicated for a single person to comprehend, let alone control. In fact, what we see today is that very thing, a collaboration of professionals in a project organization.

According to Slocum and Sims (1978:126):

> IF the TASK is redesigned by combining tasks,
>
> THEN the TECHNOLOGY will become increasingly sequential and uncertain.

IF the TASK is formation of natural work units,
THEN the TECHNOLOGY will be an increased reciprocal interdependence,
AND increased output control.

IF the TASK is establishment of client relationships,
THEN the TECHNOLOGY will be increased boundary - transaction uncertainty.

IF the TASK is a vertical loading job redesign,
THEN the TECHNOLOGY will include increased conversion uncertainty, increased output control and increased reciprocal interdependence.

Mee (1975:275-283) predicts that rapid technological advances will directly affect managerial roles. Hollingsworth and Hodgetts (1975:150-151) emphasize the tremendous impact that technology has already had on organizational structure. Suggested is:

IF the TECHNOLOGY is transitional,
THEN the informal STRUCTURE recommended
is transactional, partially delegated
or decentralized.

Luthans and Kreitner (1975:80) suggest that technology is a primary consideration in behavior modification efforts. It has the effect of either limiting or promoting the "applicability of certain intervention strategies. "Behavior modification techniques cannot be applied to performance problems caused by lack of knowledge, inefficient procedures, outdated techniques, or malfunctioning machinery." The pervasiveness of technology in the organization is further explored by Luthans (1973:280-281) as he outlines several interdependencies. His general consensus is that technology affects and is affected by, organizational structures and processes. It can be universally applied to and identified in all types of enterprises.

Woodward (1965:50-51) explains the impact of technology in a somewhat different sense. As her work clearly indicates, "technology, although not the only variable affecting the organization, was one that could be isolated for study without too much difficutly." The patterns which emerge in the analysis of the data indicate that there are prescribed and functional relationships between structure and technical demands.

Jones and Von Riesen (1978:189-190) examine the relationship between technology and role specialization in small firms experiencing environmental uncertainty. Their findings are consistent with Woodward's (1965) in that no strong relationships are found between mass-output orientation of production technology and organization size. Grissin's work (1979:21) in a similar area results in the suggestion that increased technology, concurrent with centralization of authority, may overload functional units with ever greater responsibilities and functions without providing concurrent authority, tools or adequate resources.

Traditional hierarchical power and authority and technology affects are discussed by Thompson (1975:82-92). He indicates that what is required for effective integration of influence and authority in the official structure of an enterprise is a sensitivity to changing technology and structural flexibility. Rapid technological advances preclude an ability to predict future needs; therefore, a readiness for adaptation and change is a requisite for the technical as well as social system.

Thompson (1967:15-16) categorizes technology as long-linked, mediating and intensive. Correlation among task requirements, structure and technology can be identified by use of this trichotomy. The long-linked technology is suggested to be representative of the production line composed of similar, repetitive operations. Mediating

technologies deal in standardized routines and allow the task to be extensible, i.e. it deals with repetitive tasks but the serial nature is not as restrictive. The task extends beyond structural bounds. Intensive technologies are those which consist of a variety of techniques some or all of which may be drawn upon to accomplish a specific task at a specific time.

The nature of the technology, type of structure, individual capabilities and task requirements interact to accomplish the overall organizational goals. Fox and McDade (1978:154) suggest Thompson's views are best described as socio-technical systems composed of interconnected sub-systems. Included are the technical-task, structure-process, goals-rules, managerial-control and psychosocial-ability subsystems.

Organizations such as TRW and Rand have reorganized away from the bureaucratic structure because of the technological areas in which they deal. Process (task) as well as human relations/behavior are heavily impacted by technology. Automation has been blamed for everything from creating unemployment to causing strikes. In many electronic and space industries an atmosphere of rapid obsolescence, unstable work volume, high transfer rate of personnel, and constant retraining is experienced. Individuals in high technology areas have been noted to exhibit the following characteristics (Seiler, 1967:26):

1. they form weak social relationships,
2. their loyalty to the employing institution is not developed, and
3. the individuals strive to build reputations that can be easily communicated.

One of the central problems of complex organizations is coping with uncertainty. Due to the lack of complete knowledge about technology, organizations operating even in relatively stable and predictable environments frequently face unsolved and unpredictable problems. In as much as possible, companies will seek to adjust to demands of their technological core to permit economical and efficient coordination and scheduling on interdependent parts. It appears that

1. the more predictable and controllable the technology, the more mechanistic the organizational structure can be,
2. control systems and supervisory behavior influence lower level social processes and task structures, and
3. for a large organization, and at higher levels, technology may weakly influence the structure.

Schein (1970:86) includes technology (actually he calls it "technological climate") in a class called environmental factors. He does conclude, however, that "the rapid and tremendous changes in technology...have forced the scientists

and practitioner alike to recognize the interdependency of human and technological factors and the need to develop theories and concepts which can encompass such interdependencies."

Technology: And Information Processing

The significance of technology to information processing needs little substantiation. Its impact on all organization levels is the subject of countless books. Valid, in-depth studies of the relationship of technology (information systems in particular) are not readily available. A primary factor in this lack of research is the complexity of the world in which this technology is used (Maish, 1979:40).

A major difficulty is dealing with the decision-makers, either as individuals or groups. Identification of their needs is necessary, yet as Graham (1977:69) indicates, in some cases information is needed concerning group goals, methodologies groups use to accomplish tasks, probable future action of group members and the way the group is affected by other groups. Fox and McDade (1978:155) suggest data are needed on group expectations, organization goals and task requirements. In any circumstance it is important to identify the need for a meaningful interface between the information user and the information provider.

There appears to be general agreement that MISs should be designed to be consistent with the organization structure

(MacFarlane, 1978:163). Rapid change introduces many problems with this otherwise straightforward postulate and it becomes more important to have a technology intermediary to take the organization's pulse and relate that to available technology. A mediator who is trustworthy and expert in social mechanisms as well as well-versed in technology is recommended by Singh (1977:61) to facilitate organizational communications.

Computer based information systems can be designed to function at various levels of technological sophistication to assist in performing different functions: to sense perturbations in the environment; store, retrieve and transmit data; manipulate and analyze data; develop alternatives; and disseminate decisions. There are always built-in constraints to any system that limit its capacity to perform each of these functions or that circumscribe the particular functions that can be performed by the system. The sophistication of any information system is contingent upon the extent of these designed constraints. Two categories of aids, information inventory tools and analytical decision tools, can be defined with regard to this sophistication criterion.

A computer-based data inventory aid provides basic data management capabilities for storage, retrieval, and transmittal of data. It offers an accessible and integrated memory to assist in the decision-making process. This type

of computer-based aid can be employed to organize and display a central data base gathered from diverse sources. However, developing action alternatives is still the sole responsibility of decision-makers.

A more sophisticated analytical aid is capable of projecting utilities to decision alternatives and outcomes by manipulating and correlating relevant variables on the basis of particular statistical and mathematical algorithms. These sophisticated tools operate as simulators of the decision process. Thus, they can assume some of the judgmental functions that were previously reserved exclusively for a professional decision staff.

The degree of decision aid sophistication has a direct effect on management's choice of formal and informal organization structures. However, a review of the literature indicates that aggregate results concerning the effects of technological sophistication on informal organization structure are ambiguous and inconclusive. The researchers studying this issue appear equally divided in their findings. To a large degree, these ambiguous conclusions can probably be attributed to a definitional problem. Decision aid sophistication is a temporally relative term. To a researcher of the early 1960's, sophisticated technology generally constituted an elaborate data processing and data inventorying system. Today, sophisticated technology implies a highly analytical system that is capable of simulating

actual scenarios, integrating data in accordance with mathematical and statistical algorithms, and developing sets of action alternatives to complex problems. Depending upon the precise definition of sophistication, which is apt to change over the years as technology advances, one researcher's interpretations may be entirely incompatible with those of others. The absence of definitional precision in this body of literature may be responsible for the inconclusive results in aggregate.

Rezler (1964) and Leavitt and Whisler (1958:41-48) agree that rather unsophisticated information inventory tools allow data to be transmitted upward in the organization, thus bringing about a centralization of informal interaction patterns. However, as technology becomes more sophisticated and is employed to define and analyze problems, centralized structures may become less valuable (Whisler, 1967:16-49). Taking the opposite point of view, Forrester (1967:275-281) and Carroll (1967:140-165) argue that developing an unsophisticated data processing capability will enable more decentralization within organizations. By allowing an increased flow of vital information to filter down through the organizational hierarchy, such a computer-based system can increase the number of knowledgeable individuals who are capable of making decisions and may result in increased delegation of authority (Buckingham, 1961). On the basis of a case study of computer implementation in a strategic naval

command environment, Wilkinson (1975) also concludes that computer-based data inventory tools place more authority in the hands of staff advisors.

Several authors suggest that all types of informal structure are equally probable given the introduction of computerized aids in an organization. Delehanty (1967:95-98) maintains that, even if unsophisticated data processing systems require a certain type of informal structure, there is not enough evidence to specify which one is best. Colbert (1974) maintains that computerized systems can be adapted effectively to either a centralized or decentralized structure.

Opinion is also divided among authors who consider the effect of sophisticated analytical systems on the informal organization structure. Mahoney and Frost (1974) conclude, on the basis of descriptive information of 17 business and industrial firms, that less supervisory control and more participative training and development is possible when computer-based decision aids are sophisticated, interactive, and analytic. DeCarlo (1967:244-270) also maintains that the extended use of analytical systems will cause centralized structures to disappear and be replaced by decentralized patterns of informal interaction.

Other researchers are not confident enough to posit which informal structure type is preferable to another. Carroll (1967:159-163) concludes that implementing analytical

decisions aids makes centralization of informal structure possible because top management wants to maintain control over such powerful decision-making tools; however, centralization is not essential to employing sophisticated aids. Klahr and Leavitt (1967) also see no clearly predictable effect of sophisticated decision tools on informal structure. Finally, Galbraith (1973:108-119) argues that a decentralized, informal structure is an equallly viable alternative to centralization in organizations that possess sophisticated decision aiding system.

Technology: Decision Aid Placement

Technological sophistication affects two aspects of the formal organization structure: the placement of the decision aids in the organization, and assignment to new organizational roles to effectively utilize the decision aids. The general consensus is that computer-based inventory tools are most effective when placed in a single, separate department close to the source of authority and responsibility in an organization, that is, a pyramidal installation. Whisler (1967:48) cites two trends that are both directed toward developing pyramidal formal structures. The first is a move toward placing the computer at a higher level than any other division. The second involves transferring the system out of the traditional functional departments and into a "neutral" division. Delehanty

(1967:87-89) concurs with Whisler on the proper location of computerized aids. The data processing function can be used most effectively if it is placed in a service branch or if a full status computer department is created to support the entire organization.

According to Colbert (1974), offering the data processing manager equal or higher status than other department heads allows impartial allocation of computer services among the departments. Equal status also insures that the computer is employed to serve company objectives and not the goals of any one department. Analysis of a computer-driven inventory system in the Army Material Command (1965) concurs that data processing activities are best utilized if they are under the direct control of the executive commander, thus favoring a pyramidal formal structure.

Although evidence is lacking on the proper placement of an analytical decision aiding system within an organization, it seems reasonable to assume that either a pyramidal or divisional installation would be appropriate. Complexity, cost, and functional utility make a pyramidal structure suitable if sophisticated aids are present. It is cost efficient to maintain a single, complex system (Van Paddenburg, 1972:58-60). Moreover, an analytical system integrates division level data to create an overview of the entire situation that can be interpreted by generalists at

top levels in the hierarchy. On the other hand, the argument can be made that continued technological development of mini-computers will make several divisional installations more cost efficient than maintaining single, large-scale systems (Colbert, 1974). In addition, placing analytical aids on a divisional level could provide middle and lower level managers with a clear perspective of organizational policy and status, and involve them in decision-making to a greater degree.

In organizations with either data inventory (data base management system capability) or analytical tools, Beckett (1967:232-235) finds a need for people who thoroughly understand and interpret the system and its output. Woodward (1971:55-71) and Mahoney and Frost (1974) assert that as technology becomes more advanced and analytical, a more educated staff is required. Whether these staff members should be assigned from outside the organization or trained from within the ranks of existing staff is not dealt with explicitly. However, a study of the Army Material Command (1965) specifies that systems analysts, programmers, and operators need to be assigned and integrated into the formal organization structure to interface even with unsophisticated decision tools.

Several assumptions can be derived on the basis of these studies. First, even when technology is relatively unsophisticated, there may be a need for specially skilled

personnel from outside the organization to interpret the output. Second, since analytical aids are likely to require more complex input and provide more sophisticated output, the system will probably demand that operators and analysts possess capabilities commensurate with those of the system. Especially in the initial implementation stage, effective utilization of a sophisticated decision aid will probably require highly skilled and experienced operators. However, it is conceivable that existing staff can eventually be trained to replace these analysts, but only after extensive, formal, on-the-job training.

The computer-based decision aids discussed in this research are assumed to be in an interactive mode, that is, they require on-line instructions from an analyst at various decision points to define variable parameters. Another important characteristic of decision aids, not to be equated with interactive properties, is concerned with whether they operate in real time or non-real time, that is, whether the computer system operates within the same temporal frame as the real world. A real time system performs its operations on a data base that is kept current by continual and direct input updates from automatic sensing devices and indirect updates from manual data processors. Dynamic, quickly changing situations often require real time or near real time decision aids to assist in formulating immediate choices. Real time systems speed the processing and analysis of

up-to-date information so that it is translated into fast and responsive decisions to short-range problems.

Non-real time decision aids, on the other hand, employ historical informations as a basis for analysis. While such aids may be interactive and provide quick response turnaround, the non-real time data base employed in their calculations restricts the direct utilization of their outputs to immediate problems. However, non-real time systems can provide analysts with planning assistance to make long-range decisions.

Whether or not a computer-based decision aid possesses real time capability has implications for both formal and informal organization structure. The exact type of informal structure that is most appropriate, given real time systems, is an unresolved issue. Klahr and Leavitt (1967:117-139) recognize the importance and growing availability of real time information to upper and lower levels of an organizational hierarchy. However, the kind of informal structure that is most suitable in implementing real time systems is not clear. Federico, et al. (1975) review literature on both sides of the question. Some researchers, including Myers (1967:6-7), stress the utility of real time systems for centralized management decision-making. But others assert that geographically distributed real time systems can provide information simultaneously to all levels

of an organizational hierarchy and thus make decentralization an appropriate form.

Carroll (1967) and Carlisle (1974:9-18) base their conclusions on business and military experiences with real time systems and are in basic agreement with the previous authors, in that centralized and decentralized informal structures are feasible given a real time system. Harris and Erdman (1967), dealing specifically with military commmand and control functions, also agree that the nature of technology imposes little constraint on choosing the most appropriate informal organization structure.

Galbraith (1973:108-109), on the basis of his experience in manufacturing concerns, indirectly relates real time computer systems exclusively to a decentralized pattern of informal relations within an organization. When there is a high level of uncertainty concerning a particular task, there is a great need for real time data and analysis and rapid dissemination of this information to all relevant members of the organization. Thus, a pattern of lateral relations that emphasizes communiction and coordination is most appropriate in a real time environment.

It seems reasonable to assume from the existing literature that real time decision aids can operate efficiently in either centralized or decentralized structures. However, real time systems are usually unsuitable to transactional structures because long-term,

rather than immediate, responses are usually the focus of deliberations.

It appears that a real time capability affects placement of the aiding system in the formal organization structure. Colbert (1974) and Carlisle (1974:9-17) conclude that, prior to technological improvements in computer memories and information handling speed, data processing activities had to be located at the divisional level where individuals had ready access to accurate and current information about organizational conditions and external forces. But, as technological development have provided the capacity for real time systems, conditions for a pyramidal data processing installation have become more favorable. Moreover, sensing the power inherent in real time systems to respond rapidly in limited time situations, top management prefers close control over such systems and thus favors pyramidal formal structures. Several other authors, however, suggest that the presence of a real time decision aid does not dictate the formal location of the technology (Klahr and Leavitt, 1967), Federico, et al., (1975).

> IF the TECHNOLOGY includes fully operational
> decision aiding systems,
> THEN the informal STRUCTURE should be
> centralized or consultative.

IF the informal STRUCTURE is centralized or consultative,
THEN TECHNOLOGY should consider use of analytic decision aids.

IF the formal STRUCTURE is pyramidal or divisional,
THEN TECHNOLOGY of analytic decision aids should be considered.

IF TECHNOLOGY introduces analytic decision aids,
THEN the INDIVIDUAL leader should consider temporary assignment of specially trained personnel from outside the organization.

IF the TECHNOLOGY is a real time decision aid,
THEN the informal STRUCTURE is likely centralized, consultative, partially delegated or decentralized.

If the TECHNOLOGY is non-real time,
THEN the informal STRUCTURE is likely transactional.

IF the TECHNOLOGY includes fully operational decision aids,
THEN the formal STRUCTURE recommended is pyramidal.

IF the TECHNOLOGY includes fully operational decision aids,
THEN the INDIVIDUAL leader should consider training the existing staff.

IF the formal STRUCTURE is pyramidal
THEN the TECHNOLOGY should include real time decision aids.

IF the formal STRUCTURE is divisional
THEN the TECHNOLOGY recommended is non-real time decision aids.

Based on the discussion of decision aids and their organizational location the following production rules are provided.

IF the STRUCTURE includes long distances,
AND the INDIVIDUAL requires face-to-face exchange,
THEN the TECHNOLOGY should include video-conferencing.

(Wood, Coats, Chartrand and Ericson, 1978:321)

Technology: And Data Display

The form in which output is provided decision-makers is a major physical characteristic of computer-based decision aids that has significant impact on organization structure. This variable reflects the direct interface of man and machine. The form in which computer inventory or analytical results are displayed involves software as well as hardware considerations. The format of output documentation is a function of programming forethought and initial coordination between programmers and the needs of users. Obviously, hardware features, such as individual interactive terminals and large screen projections, also determine the nature of data display.

Another variable focuses on the hardware characteristics of output displays. Individual terminals that display data and results to only one person may have a different effect on organization structure and the social aspects of small group decision-making than terminals with large screen projection capabilities. With a large screen display, all team members

can be made aware of analytical results simultaneously. Moreover, a large screen can enable them to view the output as a group rather than as individuals at separate display terminals.

The literature that deals with the relative utility and efficiency of separate units versus large screen units falls within human factors research, and is generally not concerned with the effects of output display on organization structure. For instance, Jones (1970:75-89) and Miller (1969:121-132) discuss the relative utility of hard copy as opposed to CRT (cathode ray tube) devices that are capable of graphic presentations. However, they fail to be concerned with the implications of these differences for organiztion structure.

One study by Smith and Duggar (1971) analyzes the question of whether large shared displays facilitate group participation. Using data collected in laboratory experiments, they compare group problem-solving performance of individuals using small screen displays and groups sharing large screen displays. Their results indicate that the use of small individual displays yields slower group performance. Sharing a large group display results in more rapid performance because it reduces the vested interest each team member has in his own answer; debates and arguments decrease among group members using the large screen display.

The use of individual displays can yield structures at both ends of the organizational continuum. Centralized

structures are feasible since individual displays can provide information directly and exclusively to the highest levels of an organization. Decentralized structures are equally feasible since several individual terminals, located in different divisions, can efficiently disseminate information to lower echelons. Large screen installations, on the other hand, make transactional structures most appropriate. Such display units promote total integration and communication among staff members and speed group performance, as Smith and Duggar (1971) conclude. The following can be derived.

> IF the informal STRUCTURE is transactional,
> THEN the TECHNOLOGY should include large screen displays.

> IF the informal STRUCTURE is centralized, consultative, partially delegated or decentralized,
> THEN the TECHNOLOGY should include individual communication and display units.

In terms of formal organization structure, a large screen unit will likely favor a pyramidal installation. It will enable close control by management over use of the decision aid and increased integrative capacity over the staff that views the display. Team viewing which cuts across

divisional boundaries is best served if formal coordination comes from the top, rather than if it is dispersed among separate division heads. Individual displays that are located in various organizational divisions can function best as divisional installations since they do not induce interdepartmental teamwork and, therefore, do not require intense integration from top management. Therefore:

> IF the formal STRUCTURE is pyramidal,
> THEN a TECHNOLOGY recommended is large screen displays.

<u>Technology: And Organizational Change</u>

The introduction of technological innovation into an ongoing organization can be conceived of as a developmental process. Generally, new technology cannot be integrated into an organization without a transitional phase. The requirements for debugging, reprogramming to meet specific unexpected requirements, potential staff resistance, on-the-job familiarity with system options and limitations, and the need for formal training all require a transitional stage to ease the transfer from previous methods of operation. Once the use of the new technology is routinized, accepted, and understood by the staff, the system is said to be fully operational.

Management decisions during the transitional phase will have important implications for training and assignment of outside specialists during the fully operational stage. If, for instance, experts are brought in initially to implement a new decision aiding system in lieu of training the existing staff, on-the-job training of staff members may allow the experts to be dropped during the fully operational phase. In this case, outside specialists would serve a temporary and provisional purpose. However, on-the-job training of a highly complex decision aid, no matter how prolonged, may be insufficient for effective operation of the system. It may produce heavy reliance on outside experts who are technical specialists rather than substantive experts. On the other hand, although intensive formal training of existing staff may prolong the transitional phase and make it costly, such initial efforts may yield more qualified personnel in the fully operational stage who combine both technical and functional expertise.

Whether the technology and staff are in a transitional or fully operational stage has direct consequences for formal and informal organization structure. Mann and Williams (1966) study the implications of implementing ADP on informal structure in an industrial setting. During the conversion or transitional phase, decentralization of authority was the most appropriate from of organization. Responsibility and authority were delegated and distributed to lower

hierarchical echelons, inducing teamwork and group decision-making. As the ADP system became fully operational and accepted by company personnel, the organization shifted to a recentralized informal structure, enabling more focused control and integration from above. In a similar vein, Rose (1969) contends that the transitional phase of the implementation process ushers in a period of confusion and fluidity. To handle these unstable conditions, there is a need for more decentralized or organismic organization structure. When the environment again becomes stable and predictable, the need for a loose, informal structure diminishes and the organization will assume a centralized, mechanistic form.

Technology impacts two properties of formal organization structure: the placement of the decision aiding system and the assignment to new organizational roles. There is some consensus that, during the transitional stage of implementation, a decision aiding system should be formally located at the divisional level. Van Paddenburg (1972:58-60) and Whisler (1967:16-49) observe the same trend toward developing pyramidal formal structures as computer systems become more routinized and ingrained in organizational operations.

If outside personnel with special skills are needed to operate, interpret, and coordinate the results of a computer-based system, Tomaszewski (1972:61-64) recommends

using them as a "gypsy staff" to bridge the gap between system developers and substantive users. Thus, during the transitional phase, assignment of outside specialists is preferable so that the professional staff that will use the system can become fully aware of its options and mode of operation. This "gypsy staff" provides the necessary interface between the user and system developer, but serves only a temporary role until the system and user staff become fully acclimated.

Technology has been identified by researchers as an important ingredient in every organization. The only differences are in degree and direction of application or use. The next section presents a discussion on some of the technologies available to assist decision makers.

DSS Concepts

The concept and existence of decision support systems was developed in chapters I, II, and III. A variety of relationships between computer related DSS capabilities (real-time, time-sharing and analytic aids, for example) and six organizational variables was established in the preceding sections. This section surveys the field of decision support systems, reviews current research and provides examples of various applications. These examples are only representative of the variety of the tools that may be regarded as DSSs.

Sprague (1979) provided both broad and narrow definitions for DSSs.[1] Broadly, a DSS is a computer-based system designed to aid in decision making. In the narrow sense a DSS is an interactive computer-based system which helps decision makers utilize data and models to solve unstructured problems.

The performance objectives of the DSS are:

- Support unstructured and semi structured decision making.
- Support all levels of management; to integrate between management levels.
- Support all phases of the decision making process.

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[1]The Proceedings of the SMIS conference were not available at this writing. These data were taken from notes from the conference and copies of the viewgraph

. Be process independent and user controlled.

. Support independent and interdependent decisions.

. Be easy to use.

As Keen and Wagner (1979:118) suggest "A DSS should be able to reflect the way managers think, be flexible and adaptive through ease of modification, support managers in a complex process of exploration and learning, and evolve to meet changing needs, knowledge and situations." Capabilities they suggest are included in the following design requirements.

. the development language must be flexible enough to allow rapid creation and modification of applications.

. the system's design architecture should permit quick, easy alterations and extensions

. an interface should be established to buffer the user from the computer demands thereby permitting a user directed dialogue and problem definition.

. output or display devices should be adopted to communicate or respond in a behaviorally acceptable form.

DSS Capabilities

High-level decision making is accomplished alternatively by groups and individuals. Systems to support both extrema are needed if the DSS is to evolve into the boardroom or war

room. Computer-assisted conferencing is one means to meet requirements for group decision making.

Wood et al. (1978:321) report the use of video conferencing to enhance group meetings and facilitate the exchange of information. Community views and opinions were obtained from people as far apart as Washington D.C. and California on a real-time basis resulting in increased citizen participation in congressional decision making. The result of the experiment indicated the use of computer conferencing by video, voice, data, facsimile, graphics or other means is valuable when geographical distances are great, and participants must interact in real time.

Johansen et al. (1978:319) note that the advent of conferencing requires advanced telecommunications capabilities. Individual terminals are needed to connect the groups or individuals as well as providing some method of displaying or recording their interactions. In addition, establishment of a protocol to control the exchange of data is needed.

The following rule is suggested.

IF GROUP communication is important or
necessary,
AND INDIVIDUALS or GROUP are
geographically separated,
THEN the DSS capabilities of video, computer or
audio conferencing are recommended.

Computer conferencing has been or is being used by NASA for project coordination, by the Department of Energy and U.S. Geological Survey to support research, and by the Federal Preparedness Agency to monitor crises. The Electronic Information Exchange System in New Jersey's Institute of Technology also uses computer conferencing for scientific applications. Advantages accrued, beyond real-time information exhange, are that users may respond as needed or not at all, attach to data analysis packages as desired, and use various models or data bases for information that may be useful during the conference (Johansen et al., 1978:319).

Simmons (1979:91-93) suggests the Consensor system contains the capabilities needed to enhance group decision making. This system includes a television screen for display, a central control console and limited-capability terminals for each group member. Operated by a small computer each member's degree of support for a given topic is input through the terminal and displayed on the screen as a

column of light indicating overall group agreement or disagreement. The total number of participants is indicated but no individual is pinpointed.

A reduction in time to make decisions was noted by Simmons (1979:92), as "Consensor[1] helped focus attention quickly on important issues, reduced unnecessary discussion, and provided quantified data on the level of understanding and agreement reached at the conclusion of each meeting." This technology has been used for strategic planning, budget setting, personnel evaluation and sales estimating by firms such as Avon, Chase Manhattan Bank, Xerox Corp., AT&T and DuPont. It was used by Naval officers to assess relative probabilities of alternative developments in future weapon systems technologies. The U.S. State Department used it for analysis of policy options and United Way charities executives determined funding level and distribution methods using the Consensor as an aid.

Nackel et al. (1978:1259-1265) discuss the need for a tool to enhance the group decision process with respect to resource allocation. They use integer programming to maximize program effectiveness by quantifying the decision

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[1]The Consensor is a DSS designed to permit group decision making. It uses a computer driven large screen display and individual entry devices to the computer. The computer correlates the inputs and displays the group consensus. An iterative process is used to establish group agreement or at least focus questions.

maker's goals and objectives. A linear programming (LP) model is suggested for facilities planning and resource allocation. Fidler (1977:34-36) proposes using linear programming along with a maximum likelihood model to analyze preference judgments for investment projects. A result of this work was the conclusion that these techniques were useful for both training and decision making. A LP model is used by Singh (1977:59-60) to determine the optimal hospital staff mix for an outpatient clinic, and Greenlaw (1973:19-20) uses LP for wage and salary administration problems.

Exploring the group approach further Locander (1979:61-64) describes various models appropriate for the organization. A financial planning model, using a risk analysis technique with various probability distributions, is used extensively to develop sensitivity analysis in product pricing, resource demand and investment costs. Using a team approach the requirements for the following various DSSs were developed.

- Financial models for each department were used to simulate the impact of various operating and investment scenarios using simulation and optimization techniques.
- A linear programming model for manufacturing was used to determine processing schemes.
- Transportation models were identified for determining product distribution patterns.

. Summary financial models could be used to assess the refinery projects overall affect on the firm (fed by data from other models).

Decision trees are used as a DSS by Biggs (1978:22-26) and Olson (1978:151) to describe organizational relationships. Biggs was studying participative decision making while Olson was assessing information service centralization. Results of both efforts indicate that the mere involvement of managers in building the DSSs enhanced their understanding of their respective situations.

Many organization operations lend themselves to be studied using network analysis. Pipelines, multi-plant locations, production lines, etc. are all examples of systems that fall in this category. Van de Ven (1976:72) suggests the use of digraphs (directional graphs), network theory and matrix algebra to investigate various properties of networks. Clayton (1978:196) and Moeller (1978:292) discuss variations of the graphical evaluation and review technique (GERT). GERT is a network modeling technique developed to analyze generalized stochastic networks. Q-GERT is a form of simulation using data described by a GERT model. GERT and Q-GERT are useful for such applications as determination of market share and growth (or decay), and providing probabilistic estimates of replacement demand over time.

Venture Evaluation and Review Technique (VERT) is a computerized, mathematically-oriented network-based

simulation technique designed for risk analysis (Moeller, 1978:292). While GERT is relatively time and cost oriented, VERT allows the user to select the desired scope and level of abstraction preferred. VERT has been used to assess risks in new ventures and projects, estimation of future capital requirements, control monitoring, and overall evalutation of ongoing projects, programs and systems.

Goal programming (GP) is suggested by Lee (1972:xii) as a powerful decision analysis technique for decision problems with multiple conflicting objectives. GP is an extension of linear programming (LP) but extends LP into otherwise non-feasible solutions. The GP model provides the optimum solution under a given set of constraints and priority structure (Lee, 1972:xii). It has been used in the functional areas of academic planning, financial planning, economic planning and hospital administration.

Trade-offs among multiple objectives is a capability provided decision makers using goal programming (Lee, et al. 1978:251). It may also be used to explore the fiscal impact of various levels of resource allocations. Nackel et al. (1978:1260) also suggest using GP to minimize deviations from organization goals. The following limitations, however, must be observed, when considering the GP methodology (Lee, 1972:33).

- All objective functions, constraints and goal relationships must be linear, i.e. relationships of

goal attainment and resource utilization must be proportional to the level of each activity conducted individually.

- Additivity - activities must be additive in the objective function and constraints.
- Divisibility - fractions of decision analysis variables must be acceptable, i.e. the solutions often yield non-integer results.
- Deterministic - all model coefficients must be constants, representing a static decision environment.

Carlson (1978:21-24) in his description of two DSSs, IBM's TREND ANALYSIS/370 and the Geo-data Analysis and Display System (GADS) provides a group of DSS capabilities. TREND ANALYSIS/370 is an IBM product which provides a capability to determine business trends based on various business activities associated with particular time periods. GADS is a graphics oriented display system used for planning and monitoring applications. It includes:

- analyzing and displaying data related to geographic areas,
- time series analyses,
- resource scheduling,
- map (display) editing, and
- creating and executing simulation programs.

Additional technological capabilities in GADS include

- on-line terminals; crt, graphic, and hard copy,

. mass storage,

. real time interaction,

. specialized high-level software languages, and

. data base management schema.

The primary application of GADS, which was developed as a prototype, is with the San Jose, California, police department, for scheduling and monitoring police patrols.

A variety of models are offered as decision support tools. Stein and Leja (1977:47-61) offer an impact model for estimating the possible consequences of planned changes. Chorba (1973:133) proposes a cost-benefit model to aid in objective setting, problem recognition, alternative evaluations, and in planning and control decisions. He suggests the inclusion in the model of such statistical routines as tabulations, cross-tabulations, and time series.

In 1977 Graham (1977:71-72) used a mathematical prioritization method to determine a group's feeling concerning organizational constraints (its stakeholders). An eigenvector procedure of pairwise comparisons was used to provide ratings and probability estimates for action alternatives. Hammond (1977:81) describes POLICY as an interactive DSS which includes pictorial, quantitative displays of decision maker attributes. POLICY includes the capabilities of:

. graphics displays,

. interactive operation,

. multi-variate analysis, and

. bar graphs.

Various mathematical and statistical models and their application as DSSs include:

Nackel et al., (1978:1260)	. Stochastic processes in health care to predict new disease transitions over time, diagnoses of disease and resource allocation.
	. Ranking procedures to evaluate alternative programs.
	. Integer programming to maximize program effectiveness within budget, resource, regulatory and program structure constraints.
Singh, (1977:59)	. Scheduling model for health care outpatient and treatment delivery systems.
	. Input/Output Analysis for resource allocation.

Utility models, or multi-attribute utility (MAU) models have been used to measure effectiveness of alternative program strategies, on-line selection of decision information, and industrial marketing (Nackel, 1978:1260,

Samet et al., 1976:1-1, White, 1978:179). These statistical techniques are useful in understanding the composition of groups, identifying variable interrelationships, and information filtering. Dianich (1973:19-20) used a MAU model to accomplish mission area analysis for the United States Air Force. Results of the work included the establishment of a new, 13 person office to continue the effort. Andres (1971:109) suggests that utility analysis can be used to determine value criteria for information by using it to examine the form, time, place and possession utilities of that information.

Simulation techniques and heuristic problem solving are recommended by Leavitt (1974:37) for organizational change planning. Greenlaw (1973:25) proposes simulation to study union health and welfare trust fund management policies. Large scale simulations, and heuristics in general, have not been considered seriously as DSSs because of the need for voluminous data gathering and necessarily detailed scenario preparations. However, as technology advances both simulation and heuristic problem solving will become available as DSS tools.

The techniques of applied Bayesian statistics provides another approach to constructing DSSs. Andrus (1971:108) suggests the Baysian approach for examing information flow. By discounting the value of perfect information for uncertainty, an expected value of information can be derived.

A group DSS described by Andriole (1979:15-17) includes Bayesian techniques with graphics displays and a real-time communications capability. Figure III-6 illustrates the schematic of this group decision aid. An intermediator enters participant decisions into the computer while the director moderates the group's actions. This aid has been used for evaluations of proposed courses of actions.

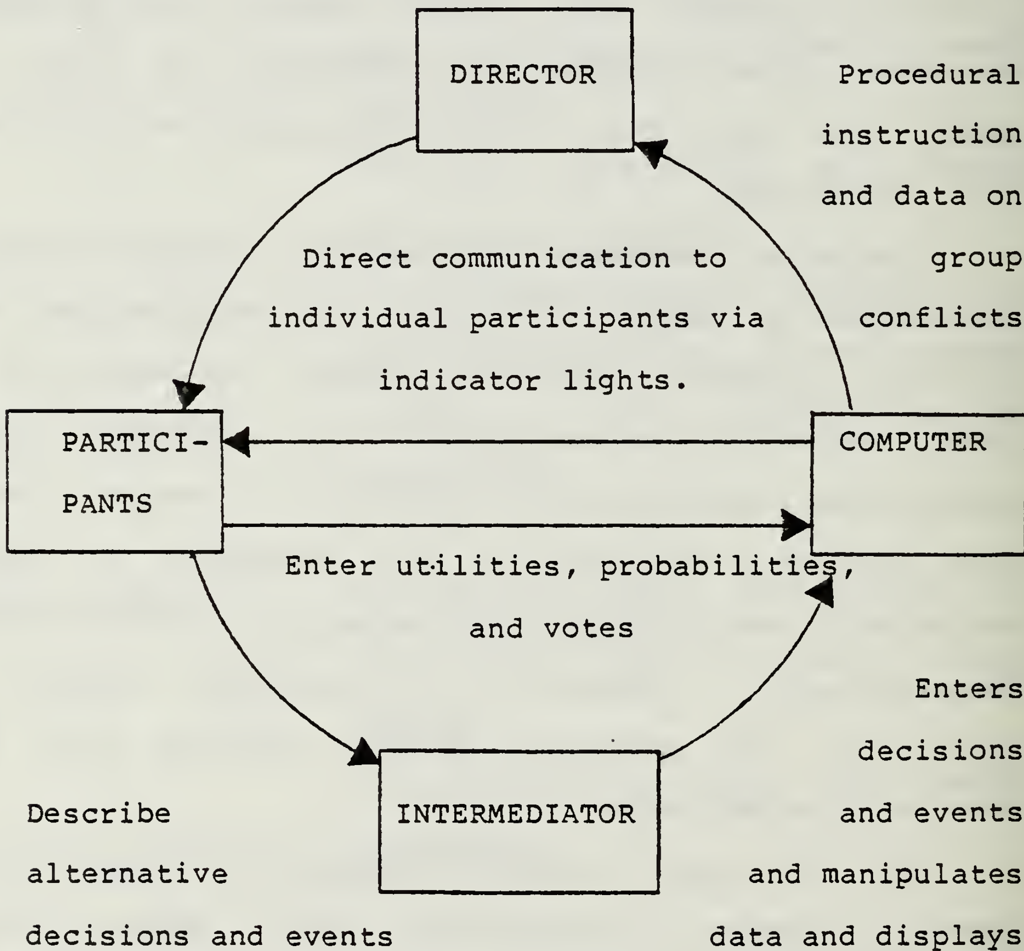

Figure IV-6. Computer-Aided Group Decision Aid
(Andriole, 1979:16)

Dana Corporation (Halbrecht, 1979:3) has established a unique DSS capability. Their information center maintains a hand-updated grease board which the executives may scan at will with a video camera. When data arrives at the center which is pertinent to an individual manager the center operator can signal the approgriate manager by activating both audio and video alerts.

Morgan (1975:3-22) has designed a system called the Decision Aiding Information System, or DAISY, which to a large extent automates what the Dana Corporation does by hand. DAISY is designed to provide mid-management decision makers the capability to integrate the latest information systems, modeling, and probabilistic estimation techniques into their own decision making activities. It includes data base management techniques such as alerters. Alerters provide dynamic data base scans and upon detection of previously defined conditions a variety of alerts are provided the managers. In some instances, pre-selected options may be activated. DAISY uses capabilities such as on-line, real-time interaction, and a sophisticated data management system. A windowing display technique is also employed to facilitate human-system interaction.

The Generalized Management Information System (GMIS) is discussed by Donovan (1976:344-369) as an example of a DSS. GMIS includes, as an integral part of its design, data management capabilities, modeling languages and statistical

packages. In later configurations a virtual machine concept which included a network of shared data and computational power was designed. A user oriented query language (called QUERY in this case) is included in the GMIS package as is a plotting capability.

GMIS was initially designed to assist the New England Planning Commission in managing the distribution of crude oil. By the time it has been implemented, six months later, the problem had changed from distribution to energy pricing. The environment faced by the GMIS designers is typical of those within which a DSS must operate. That is:

- the problems are continually changing,
- answers are needed quickly,
- data necessary to perform analyses are difficult to capture,
- more than raw data are needed because of the complex nature of the problems,
- sophisticated analysis, transformations, displays, projections, etc., are also needed, and
- rapid implementation, robustness and effectiveness are much more important than efficiency.

DSS capabilities range from a single user satisfied with a simple statistical calculation to multiple users interacting with one another in time critical situations. The following represents possible DSS capabilities that should be considered. The list is suggestive in nature only

and does not represent an exhaustive enumeration of possibilities.

display group:	graphics, color, large screen individual, windowing, alphanumeric, hard copy, audio and video.
terminal group:	remote job entry, interactive, split screen, voice,
data base group:	data base alerters, distributed data, knowledge representation, relational, multi-source fusion, centralized, decentralized
processor group:	real-time, batch, networks, word processing, text editors, on-line, large-scale, mini, micro
language group:	menu style, user-oriented, inquiry and retrieval, natural language, single vs. multiple languages, high level, simulation, conversational,
model group:	multi-attribute utility, simulation, linear programming, goal programming, automatic message handling systems, regret matrices, predictive and forecasting, heuristic, statistical, Bayesian, and transportation models, EOQ, trees,

report group: ad-hoc, exception, bar-charts, selectable user profiles, hard copy

A large number and variety of CONDITION-->ACTION combinations can be developed from this review of DSS capabilities. The following is provided as a representative list.

<u>Summary of DSS Production Rules</u>

IF a significant number of calculations are required,
AND there are pressures for quick response,
AND fast, accurate answers are needed,
THEN the DSS capabilities should include computer driven on-line, real-time, expert assistance, direct individual interaction with the DSS.

IF the decisions affect several functional areas,
THEN the DSS should be group oriented, have group responsibility, and have multiple output.

IF the product market potential is modeled,
  OR projected demand is wanted,
THEN the DSS should include forecasting
  methods,
  OR consumer surveys.

IF the ENVIRONMENT includes complex,
  multiple conflicting constraints and
  objectives,
THEN the DSS should consider including
  goal programming techniques.

IF the problem is complex,
  OR there is a significant investment
    in labor, materials, or money,
  OR uncertainty is involved,
  OR there are different values or
    preferences which can be elicited for
    various outcomes,
THEN the DSS should use decision analytic
    (analysis) techniques.

IF the ENVIRONMENT is satisfying,
AND the GROUP type is Nominal,
AND the problem (TASK) is FOCUSED (well defined),
THEN INDIVIDUAL interative displays are recommended also.

IF the ENVIRONMENT is satisfying,
AND the GROUP type is sequenced brainstorming,
AND the problem (TASK) is focused,
THEN large GROUP displays with multiple inputs are recommended.

(Stead, 1978:176)

IF the ENVIRONMENT has limited resources,
THEN consider TECHNOLOGY of linear programming to optimize resource allocation.

(Luthans, 1976:171,228)

IF the ENVIRONMENT consists of constrained resources,
THEN DSS is needed in the area of resource allocation.

Summary

Chapter IV, Organizational Variables and Decision Support System Capabilities, has provided an in depth review of the literature concerning the six organization attributes, groups, environment, task, structure, individual and technology. These attributes and their complex interactions are proposed as sufficient to completely describe any organization process. The depth of the literature review was necessary to establish the validity of this proposition.

The last section of this chapter is a review of the literature on decision support systems and their capabilities to support the same organizational process. Within the review both technical aspects and operational applications of DSSs are discussed. There are literally hundreds of variations of models and techniques that would be appropriate for inclusion here, however, a representative sample is provided.

Throughout this chapter an attempt has been made to provide production rule (IF CONDITION-->THEN ACTION) structures within the discussion, as in the GETSIT sections, or summarized, as in the section on DSS capabilities. The purpose for this was twofold. First it is a method to focus the discussion on specific contingent relationships among two or more variables or between the variable(s) and DSS capabilities. Second, and equally important, these relationships are nearly in the form used in adding knowledge

to the DECAIDS system. By selecting the appropriate appendix the naive user could introduce new expert knowledge to DECAIDS. As new literature and research appears new rules may be added thereby increasing the value of such a transfer agent.

The following chapter extends this work to include a concentrated effort to collect similar data directly from corporate managers. As in this chapter, additional production rules are constructed.

CHAPTER V

INTERVIEWS

Introduction

Chapter IV reviewed the literature concerning research on the six organizational variables, group, environment, task, structure, individual, and technology. It concluded with a review of various DSS tools and methodologies. This chapter discusses the instrument used for data collection and on-site interviews conducted by the author with 43 corporate managers of 14 different firms. The interviews, the majority of which were tape recorded, took place at the respective corporate headquarters. This study presents only summarized data in order to protect proprietary information concerning specific corporate operations and policies.

Oppenheim (1966:26) points out that voluminous data are not required to develop a prototype system. A number of production rules were developed in the preceding sections to examine the propositions stated in Chapter I; however, the question remains as to the relevancy of the literature to the active corporate community. In addition, the question of bias has not been addressed. The majority of the literature is written by academicians or research firms and not by practitioners. A minimum number of writings and published

reports are prepared by present-day, on-going decision makers.

The purpose of the interviews is to reduce bias and inject the decision making element (the corporate official) into the research. Interview data will also provide additional production rules for the model.

The very subjective nature of corporate decision making introduces a high degree of difficulty in quantifying data which reflects the decision maker's interaction in an organization. Application of the production rule methodology used in artificial intelligence applications discussed earlier provides a possible solution. Data collected through the focused interview will be translated into various IF CONDITION-->THEN ACTION (production rule) statements with attached probabilities. These probabilities (certainty factors discussed in Chapter II) reflect the degree of certainty expressed by the respondent. When added to the knowledge base acquired by the literature previously reviewed the validity of the prototype system will be considerably enhanced.

<u>Selection of Candidate Companies</u>

The Dun and Bradstreet Million Dollar Directory (1979) was used to initially identify prospective sources for interviews. In addition, Prof. S. Lee, at the University of Nebraska, provided several references. An effort was made to

obtain a cross section of companies with respect to size, geographic location and primary function. This was done to obtain as broad a perspective as possible concerning decision making requirements, capabilities and situations.

Figure V-1 summarizes the corporations used in this study by geographic dispersion, size and income. The ranks of the interviewees are from corporate president to division manager and their time with the organization ranges from 2 months to 33 years, with the mean at 15 years.

GEOGRAPHIC LOCATION	REVENUE (APPROX)	EMPLOYEES (APPROX)
Chicago, IL	$17 Billion	400,000
Chicago, IL	$3.52 Billion	21,000
Honolulu, HI	$1.02 Billion	37,800
Honolulu, HI	$857 Million	12,500
Los Angeles, CA	$300 Million	6,000
Minneapolis, MI	$1.5 Billion	42,000
Minneapolis, MI	$3.0 Billion	82,000
Omaha, NE	non-profit	20,000
Pittsburgh, PA	$3.5 Billion	45,000
Pittsburgh, PA	$6.14 Billion	120,000
San Antonio, TX	$10 Million	200
San Antonio, TX	$56 Million	4,200
San Francisco, CA	$66.5 Million	73,000
San Francisco, CA	$2.9 Billion	50,000

Figure V-1. Interview Respondent Data.

A letter of introduction, Figure V-2, was sent to each firm considered in this study. Its purpose was to introduce the research and elicit an invitation to visit the organization to conduct interviews. The major points of the cover letter were (1) introduction of the research, (2) request for permission to visit, (3) an explanation of the level of management desired for the interview, and (4) an offer to provide additional information.

Data Confidentiality

Under ideal academic circumstances the data analysis for a research study would explicitly identify sources for each data point, thereby permitting attempts at replication. While an effort will be made to permit replication, if desired, circumstances do not allow such exactness. Each respondent was assured that confidentiality concerning specific business interests and practices would be maintained; therefore, the data analysis will reflect generalized and aggregated interview results instead of specific, individual responses. However, these conditions should have little effect on the overall validity or use of the prototype model.

Mr. John Doe
Doe Corp.
1 North ST.
San Francisco, CA 94119

29 May 1979

Dear Mr. Doe:

I am a professor at the Naval Postgraduate School, Monterey, California, and am conducting research concerning the value of automation to support managerial decision making. I've developed a computer model to analyze the correspondence between various organizational aspects of management and computerized decision aids. What I must do now is collect relevant data to extend and validate the model.

Your firm represents a valuable source for such data. Would you agree to my visiting your corporate staff for interviews? All data collected would, of course, remain completely confidential.

The resources for the data collection should ideally include interviews with three of your corporate officers, or one corporate member and two staff personnel. I would prefer a representative from the data processing group, someone of equal organizational status from a user area (marketing, or production, or etc.) and, finally, someone higher in the organization who has an overview of the responsibilities and organizational interaction of the first two. The purpose of the third person is to provide a more global perspective than obtained from the others. A structured interview will be used so I must personally interface with each individual.

This has been an intentionally brief introduction to my work as I appreciate your demanding schedule. I will be happy to forward details of the study and a copy of my interview guide upon request. The bottom line is that I would appreciate an invitation from you to visit your organization and continue this research. I am available from July through September at your convenience and look forward to your reply.

Very respectfully,

Ronald J. Roland
Dept. of Computer Science

Office (408) 646-2269/2449
Home (408) 649-1976

Figure V-2. Letter of Introduction

Survey

The data collection was conducted from July through October 1979. Funding for the travel was furnished by a research grant from the Naval Postgraduate School, Monterey, California. Each firm was provided a copy of the research proposal and the survey instrument prior to the interview. In addition, a brief synopsis of the project was provided at the beginning of each session.

In three cases respondents had filled in the survey instrument prior to the interview. They were thanked for their effort but informed that in order to be consistent the data had to be collected in a standardized manner. Agreement was reached in all cases.

Instrument

On-site data collection was accomplished using the structured interview guide (Appendix A) developed specifically for this research. The instrument was formatted to guide rather than drive the interview. The main body of the interview includes a separate section on each of the six organizational variables, a section on DSSs, and a wrap-up section. Since the purpose of the meetings was to direct attention to specific organizational variables, a focused interview perspective (Seltiz, et al., 1976:318-319) was adopted.

In the focused interview a list of topics, the interview guide in this case, is derived from a formulation of the research problem. The list is used as a framework of topics but the manner in which the questions are asked and their timing are left to the interviewer's discretion. This provides the necessary freedom to explore possible reasons and motives, and probe into unanticipated directions. This type of instrument is not a precise measurement device; however, it does provide additional tests for the propositions and data for constructing additional production rules.

The interview guide (Appendix A) provided a framework of topics so all interviews could be similarly structured, but allowing the participants to elaborate in areas of their choosing. The reference point for the interview was the verbal introduction explaining the purpose of the research and recording administrative data such as the name of firm, type of business, respondent's name, position in firm and interview date. Each company had been provided a detailed description of the study; however, the author's suggestion to quickly review the purpose of the interview was well received. Finally, a brief description of each of the variables was provided.

The questions used in the interview were of two distinct types, open and closed ended. In general, the open ended questions were used to elicit verbal descriptions of

organization characteristics. For example, the question, To what formal groups do you belong within the firm?, was used to obtain verbal data concerning formal groups.

Closed ended questions, or continuums, were designed to obtain data in areas that could be bounded by some set of parameters. For example, respondents were asked to quantify how they perceived the firm's environment on a range from stable to dynamic. These responses were placed on a scale from 0 to 10, which represented extremely stable to extremely dynamic respectively. It is adequate for this research to use approximations in many areas and by establishing such boundaries the interview time itself is reduced. A variety of continuums were used and the response to this method was very positive. In retrospect, the respondents generally seemed more receptive to this type question than to the other. It also seemed to reduce the interview length, another unpredicted bonus.

The first section of the interview guide is composed of open ended questions. It dichotomizes the organization variable Group into FORMAL and INFORMAL. Question 1a and 2a deal with group membership. The literature suggests these are the two basic group structures and these questions are used to determine the interviewee's awareness in each area. If the response is positive in either or both 1a and 2a, then the remaining questions under group are used to provide data concerning specific group characteristics and details on the

use of automated support. If the response is negative to either 1a or 2a, no further data are collected concerning that group type.

Section two concerns the organization's environment. Unlike group, the literature on environment provides certain specific parameters that may be used as end boundaries on continuums. Three such continuums were used to record 1) the degree of organization stability, 2) the source of information for decision making, and 3) the nature of the environment from operational control to planning.

Environment questions four and seven were included so that the respondent could discuss any automated support that was recalled while discussing the environment. External and internal factors that affect decision making are of direct concern to the use or possible use of DSS capabilities. If, for example, internal factors are identified as very significant, it is possible that the organization may have data available in some form that could be retrieved and formatted in such a way as to aid the decision maker. A DSS capability using data base management techniques could be a possible result of such an identification. Therefore, it was important to collect data on external and internal factors which was accomplished using questions 5 and 6 under environment.

Collection of data on the variable TASK was also amenable to the use of both open and closed ended questions.

A verbal description of each manager's task was requested by question 1. This question was used to provide the author a description of the task as perceived by the manager. Its secondary purpose was as a lead-in to closed-ended task questions 2a through 2e which provided an approximation of the manager's overall view of his/her task within the organization.

The time frame, cost implications and value, in task questions 2c, d and e respectively, were purposely left undefined because of the variety of managers and tasks that could be encountered. In addition, it was important to have the respondee quantify these independently and provide their own definitions. Finally, question 3 under task is a reminder to review automated support used to aid the manager in accomplishing tasks.

Organization structure, the fourth GETSIT variable, was divided into the areas of formal and informal. Again the literature strongly supports the existence of both types of structure in all organizations. Within each there is one identifiable continuum, LINE-MATRIX for the formal group, and CENTRALIZED-DECENTRALIZED for the informal group.

The literature is also quite expansive on various specific levels of formal and informal structure between the bounds of the possible continuums. One open ended question in each area was used and the respondent was then free to

select one of the specific levels, with or without elaboration or could verbalize a combination.

Question 2 in the section on organization structure was a request for an organizational chart and if the respondent considered the chart a reflection of how the organization really operated. This question satisfied two needs. First, it would provide documentation useful in validating collected data, and second, it is useful in understanding some responses to structure questions. For example, when a chart is available indicating a line and staff structure, and the respondent indicates the formal organization is matrix, and the organization chart represents his perception of the firm, a contradiction is noted in the data reduction. There were only a few cases of this happening.

The literature indicates that individual leader styles vary from the very technical to the very human-oriented. Data on the respondent's background and concern for these two job aspects were collected from questions 1a and 1b in the section concerning the individual. Question 1c was included because of an initial desire to determine the proximity of a MIS function to the individual. No meaningful data were collected from individual question 1c as many respondents could not identify with the information analyst function.

Queries on the degree of group interactivity were the purpose of questions 2a, b and c. Responses of group consensus, managing others' initiatives, and communicating,

were expected of managers claiming to be people oriented. Opposite responses would indicate strong interests in the technical and individual aspects of the job, and therefore a much different leadership style.

Three categories of leader style were presented in question 3 under individual. A range of very individualistic to very human oriented can be postulated across questions 3a to 3c. Expectations were that more technically inclined leaders were either 3a autocratic, or 3c laissez faire, while people oriented leaders would tend to the center. A mixture of styles was also anticipated.

Parts 4 and 5 were further attempts to identify underlying interests in technology versus people. In question 4 effectiveness and people were synonymous while efficiency and work centered interests were similarly associated. A consistent response was considered one that had a relatively even weight for both items in a given pair.

There are four parts to question 5 within the section concerning the individual. Consistently high responses in item 5 suggest strong leanings toward interest in people. The opposite is also true. Low responses overall indicated a greater interest in the work or technical task. In retrospect, a review of the data suggest a strong feeling among most managers that they had to assert they were very democratic and they were primarily people oriented.

Technology was the last of the six organizational variables to be discussed. At this point in time the respondents had answered questions concerning automation and automated aids. Data concerning the firm's technological capability were collected using four continuums. An explanation of each of the terms, tools, methods, skills and machines was verbally provided. Tools were explained to include software and data manipulation capabilities while the term methods is used to identify specific models or mangement science techniques. The level of skills indicates the degree of technological skills available in the firm and machines refers to the hardware in current use.

Questions concerning the use of automated aids were included on three of the six organizational variables. The section on DSSs was intended to review what had already been covered and explore additional possibilites. It was introduced with a definition and description of a DSS. It then attempts to categorize those in use, what may be needed, or some future application.

The wrap-up (and final) page of the interview guide was included to provide the interviewee the time to comment on the study, the interview, the interviewer, or whatever. It also provided a graceful means to terminate the session or let the respondent expound on an otherwise limited response. It in fact provided feedback concerning the conduct of the

interview, its relation to corporate activities and applicability to future research.

This instrument was designed as an interview guide to elicit the manager's perception of a firm. As such some of the questions were to be thought provoking as well as a prompt for data. It is important to keep in mind that it was the manager's perception of these variables that was being collected. For example, if the response to MACHINES in TECHNOLOGY was very low and yet the firm had the newest hardware, as far as the study is concerned the use of that technology to support that decision maker was low.

Data Discussion/Analysis

Data reduction was intially accomplished by extracting information from the interview guide and placing it in the format shown in Figure V-3. Responses were quantified where practical, for example, the use of the continuum approach concerning the environment, task, and technology variables, was very conducive to this approach. Due to the detail on this form and the requirement for information protection, these data are not explicitly included herein.

ORGANIZATION # ____________
TYPE OF BUSINESS ____________
INCOME IN $ BILLIONS ____________
NUMBER OF EMPLOYEES ____________

Respondent	A	B	C	D
Position Title in Firm				
LEVEL FROM TOP				
GROUP: FORMAL				
#:				
Decisions Made:				
Size:				
Permanency:				
Aids Used:				
GROUP: INFORMAL				
#:				
Decisions Made:				
Size:				
Trends Set:				
Aids Used:				
ENVIRONMENT: 0-10				
DYNAMIC:				
EXTERNAL:				
PLANNING:				
EXTERNAL-FACTORS:				
INTERNAL-FACTORS:				
TASK: DESCRIPTION				
STRUCTURED:				
GROUP ORIENTED:				
TIME:				
COST:				
AIDS USED:				
STRUCTURE:				
FORMAL:				
INFORMAL:				

Figure V-3. Data Reduction Format.

Respondent		A	B	C	D
INDIVIDUAL:					
	Technical Background:				
	Planning:				
	Communicating:				
	Review: Accomp:				
	Daily:				
	Dictator:				
	Democrat:				
	Laissez Faire:				
	Effectiveness:				
	Efficiency:				
	People:				
	Work:				
TECHNOLOGY:	Tools:				
	Methods:				
	Level of Technology:				
	DSS Currently Used:				
	Would like to use:				
	Misc. Notes:				

Figure V-3, Part 2. Data Reduction Format.

The organization levels of 43 respondents are shown in Figure V-4.

Corporate Level		Number Interviewed
0	President	1
1	Exec. Vice Pres.	2
2	Sr. Vice Pres.	2
3	Vice Pres.	15
4	General Manager	11
5	Manager	12

Figure V-4. Corporate Levels Interviewed.

This figure is included to illustrate the variety of corporate levels interviewed. No effort is attempted to normalize the responses based on corporate level or size (gross income or number of employees) of the organization.

Figure V-4 provides the basis for a table (Table V-1) from which relative assessments were derived. In order to provide some perspective on the respondents overall, two corporate levels, A and B, were established. A includes the levels 0 through 3 of Figure V-4 while B include 4 and 5. This division permits analysis based on relatively even samples in each level.

CORP. LEVEL	NUMBER INTERVIEWED	VARIABLE: ________ CHARACTERISTICS			
		A	B	C	D ...
A	20				
B	23				

A. Participant

B. Make Decisions

C. Use DSS

. .
. .
. .

Table V-1. Corporate Response Summary.

Group

The definition of a formal group as defined in Chapter IV excluded consideration of an organization as an example of a formal group. Table V-2 reflects this understanding and indicates responses to selected parts of the interview. This data may be used to provide supporting arguments for a variety of production rules.

Variable: GROUP										
		CHARACTERISTICS (%)								
CORP. LEVEL	NUMBER INTERVIEWED	A	B	C	D	E	F	G	H	I
A	20	100	42	43	0	52	55	55	0	45
B	23	82	26	43	9	48	36	55	0	73

where A = Formal Group Member

B = Formal Group - make decisions

C = Formal Group - make recommendations

D = Formal Group - use decision aids

E = Informal group member

F = Informal group - make decisions

G = Informal group - set trends

H = Informal group - use decision aids

I = Informal group - linker

Table V-2. Group Interview Response.

All top level managers identified themselves with one or more formal groups while level B responses were 82%. Decision making in groups was seen to be much greater at higher levels than otherwise. Making and forwarding recommendations were equally identified by both groups. Four

officials, all from the B group, said they could not identify any formal group other than their organizational element which has been excluded by definition. Only two examples of computerized aids (closed circuit television and a statistical model) were used for formal group interaction and these were in group B. Display and information aids used by all respondents included over-head projected viewgraphs and various computer printed summaries. Overall group sizes ranges from 5 to 650 with a mean of 7.

A certain amount of difficulty was expressed by many respondents in identifying with the concept and reality of informal groups. Approximately 50% of all participants considered they were members of informal groups. Of those who indicated they belonged to some informal group a greater number from group B emphasized both decision making and trend setting. Group B members also strongly identified with the linker or information exchange element.

Decision aids suggested in support of the overall group functions included an automated budget process, ad hoc computer inquiries (on-line but not necessarily real-time), automatic message handling systems, and on-line conferencing. All participants used computer generated hard-copy print-outs for group oriented activities.

Environment

The interview guide for environment began with three continuums. Respondents were initially asked to describe their environment on a range from stable to dynamic. Discussion was encouraged through the whole interview but a point on the continuum was used for data. Table V-3 shows the aggregated results.

CORP. LEVEL	NUMBER INTERVIEWED	VARIABLE: ENVIRONMENT CHARACTERISTICS (Range 0-10)		
		A	B	C
A	20	6.9 (6)	3.6 (5)	7.4 (8)
B	23	5.4 (4)	2.9 (3)	5.3 (5)

0 <--------------> 10

A.	Stable	Dynamic
B.	Internal	External
C.	Operations	Planning

Table V-3. Environment Interview Response Means
(Medians shown in parentheses)

In this aggregation it is clear that level A managers had a view of their environment as overall more dynamic, externally oriented and more involved with planning than level B managers. As the two groups are very similar in a

hierarchical sense, these close results are consistent. On the first continuum the median of groups A and B are 6 and 4 respectively, indicating that more of level B responses were on the stable side of the scale than level A responses. This implies the higher level managers as a group viewed the environment as more dynamic or uncertain than level B managers.

The predominant feature of question 2 concerning the source of information used for decision making was identification of its internal nature. Both levels averaged below the mid-point of their continuums. Calculation of the medians indicated group A (median=5) viewed external information slighty more relevant than group B (median=3).

Responses from question 3 concerning operational control versus the planning environment indicate the majority of all respondents considered the planning environment more relevant. Separation over the range, 5.3 to 7.4 and calculation of the medians (A=8, B=5) indicate the stronger feeling of group A for planning. During the interviews the lower level managers expressed greater feeling and concern for operational control matters than for long-range or strategic planning.

Few automated aids beyond computer print-outs were used by the respondents. The following list is a combination of identified capabilities in use and those suggested as being of possible benefit.

strategic forecasting models,

data networks for messages and retrievals,

on-line retrievals,

statistical packages oriented to the non-statistical person,

graphic display capability for planning,

data base management system, and

crt displays.

Task

Data on the variable, task, were collected using five continuums. Included were the structuredness of the task, whether it was a group or individual oriented function, time allowed to accomplish the task, its cost impact, and criticality to the firm. The ranges of these continuums are shown at the bottom of Table V-4.

Based on the response means in Table IV-4, it appears that both management groups held similar overall views. Analysis of the medians supports the mean indicating that group B (the lower level group) viewed their tasks as less well structured than group A, an indicator somewhat opposite to current literature. The group orientation data indicating group B slightly more group oriented than group A was also supported by calculations of their respective medians. Similar support was found for areas C, D, and E.

CORP. LEVEL	NUMBER INTERVIEWED	VARIABLE: TASK CHARACTERISTICS (Range 0-10)				
		A	B	C	D	E
A	20	5.0	5.7	5.7	7.9	6.2
B	23	6.5	6.3	5.4	5.9	6.2

0 <----------------> 10

A	STRUCTURED	NON-STRUCTURED
B	INDIVIDUAL	GROUP
C	SHORT TIME	LONG TIME
D	LOW COST	HIGH COST
E	LOW VALUE	HIGH VALUE

Table V-4. Task Interview Response Means.

The automated support identified by some respondents for task accomplishment included planning models, time-share or dedicated access to computing capabilities and real-time modeling.

Structure

The section on structure was designed to determine the degree to which the respondents were aware of formal and informal organization structures within their firm. It provided a means to determine if a formal organization chart exists and to obtain a copy. Five charts were not obtained, one because it contained proprietary information, one was not mailed, and three did not exist.

Responses to the questions were straight forward. Group A indicated a predominant trend for the staff or line-staff formal structure while group B was more line oriented. The formal structures were strong on either end for both groups with B emphasizing centralization and A somewhat evenly split. Three responses, one level A, did not acknowledge the existence of a formal structure and eight, two from level A, did not perceive any informal structure. One manager responded to questions about structure saying that neither existed in her organization.

CORP LEVEL	NUMBER INTER-VIEWED	VARIABLE: STRUCTURE CHARACTERISTICS										
		A	B	C	D	E	F	G	H	I	J	K
A	20	5	11	1	3	5	2	6	4	2	0	7
B	23	9	7	4	2	5	3	9	0	2	2	4

A	LINE	F	NO ORG. CHART
B	STAFF (or line-staff)	G	CENTRALIZED
C	FUNCTIONAL	H	CONSULTATIVE
D	MATRIX	I	TRANSACTIONAL
E	OTHER	J	PARTIALLY DELEGATED
		K	DECENTRALIZED

Table V-5. Structure Interview Response.

The number of responses, if summed, do not equal the number interviewed because some respondents indicated structural mixes in their organizations. In the formal group, several subjects suggested their firm's structure were combinations of line and functional (1), functional and matrix (3), line, staff and function (1), and line and matrix (5).

Mixed responses concerning informal structure included one occasion each of centralized-consultative-decentralized, centralized and partially delegated, and centralized-consultative. When asked why the differences in structure composition the typical response was that the structure at any point in time was contingent on the task and environment.

Individual

The educational background of the respondents ranged from Ph. D. (2) to high school graduate. Technical and non-technical backgrounds were about evenly divided. Interest in technical versus people aspects were evenly distributed between both groups, however, there was an indication that the level occupied in the organization and the length of time with the firm has strong influences on how people oriented an individual seemed to be. High levels and long employment record were associated with a higher regard for people than technology. The same distinction held for

questions 2b and c, that is the longer tenure, high-rank individual spent the major part of the time managing others and communicating.

Only three responses indicated anything other than a democratic style of leadership for question 3. One case of laissez faire style leader was because the manager's employees were all highly educated, self-starters, who worked either as individuals or at most with one other person on highly technical tasks. Two explanations of the autocratic style were that while the workers were professional, the manager ran a "tight shop" and had to be certain that the tasks were being accomplished "in the appropriate manner."

Both groups consistently rated interest in effectiveness higher than interest in efficiency (70% to 30% average) with a similar treatment of people versus work on question 4. Several respondents explained that in their positions they were "expected" to be interested in people and had to stop being concerned as much about efficiency. One member with a strong engineering background elaborated on his discomfort with the transition that was occurring as he moved up saying he secretly wanted to "work on some real tangible problems again."

Members of level A responded with very low numerical responses to question 5, while group B were slightly higher but not over a mean of 50%. Discussions with respondents suggested that at the management levels being interviewed

very little goal directing and monitoring was done in any explicit manner. The majority of the respondents were relatively independent and had identified closely with organizational goals. The need for setting goals, measuring progress and coaching subordinates was not a concern at this corporate level.

Technology

Some degree of automated support was available to every corporate official interviewed. For example, all of the companies (Department of Defense example included) had on-line computer capabilities at some level in the organization. In using the focused interview it was the case that the respondent had to be reminded that we were discussing their personal perspective and (therefore knowledge) of available resources and not the corporate use.

A previous description explained the terms tools, methods, skill levels and machines. Several responses, 31%, were straight lines, that is one value was used for all four items. Characteristic averages over both groups was relatively even as were modal calculations. The only slight differentiation was that group A consistently rated the item machines higher than group B. This possibly indicates that the higher level group as a whole felt the organizations were strong in the use of high technology automated support. No

data were collected to determine the rationale for these feelings.

CORP LEVEL	NUMBER INTERVIEWED	VARIABLE: TECHNOLOGY CHARACTERISTICS (AVERAGE)			
		A	B	C	D
A	20	6.13	6	6.13	8.5
B	23	6.7	5.8	6.6	6.8

A. Tools

B. Methods

C. Technological Skill Level

D. Machines

Table V-6. Technology Interview Response.

Decision Support Systems

Various sections of the survey instrument, i.e. group, environment and task, included a request for a description of automated aids used to support that particular area. Six of the 43 respondents, one vice president, three directors and two managers, indicated a degree of use of automated support beyond the computer generated, hard-copy (paper) report. Two of the six represented the DP or MIS function. In all other cases the only direct computerized assistance acknowledged by the respondents was the availability of various hard-copy reports.

DSS Capability	No. of Responses	Group A	Group B
large scale display	2		2
network models, i.e. PERT, CPM	4		4
budget and salary models	1		1
automated message handling	2		2
on-line crt inquiries	11	3	8
audio I/O	1		1
planning and forecasting models	6	1	5
DBMS	5		5
statistical packages	3		3
time-share	4	2	2
financial models	6	4	2
on-line graphics for planning	1		1
teleprocessing	1	1	
fast data base access	2	1	1
bid preparation models	1		1
vendor slection models	1		1
performance criteria models	3	1	2
project/resource scheduling models	1		1
marketing models	2	1	1
"what if" capability desired	3	2	1
data base alerters	3	1	2
decision criteria selectors	1		1
tax models (audits, sales, returns)	1		1
sensitivity, cash-flow and corporate analysis	2	1	1
real-time retrievals	4		4
simulations	2		2

Figure V-5. Desirable DSS Capabilities.

This section on decision support systems was an effort to introduce the concept of a DSS and determine 1) the subject's awareness of the tools and 2) their receptivity of the concept. The tabulation avove (Figure V-5) lists the DSS capabilities that were suggested by various respondents as having some possible value with the number of times that

capability was suggested.[1] It also includes an annotation of the recommendations by groups A and B.

Almost all repondents indicated that batch processing was an acceptable method of receiving decision making information. Hard copy prints are the universally accepted mode of information display. As one person may have suggested more than one capability the total number of responses should not be construed as a percentage of the total sample.

The survey indicates that at higher organization levels less need is felt for DSS capabilities. Even in firms that are highly automated, upper level executives are averse to directly accessing information for two possible reasons. One is the concern about wallowing in masses of detailed information and the other is the view that theirs is a level of administration beyond management. The data are necessary for the organization to function but not pertinent to their individual purposes in the firm.

Several DSS capabilities were suggested with the caveat that the person recommending them would not use them but they would be "good" for subordinates. An effort was made to

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[1]While several capabilities shown are rarely user controlled, e.g. PERT/CPM, budget and salary models, and several that are never user controlled, e.g. planning and forecasting, statistical packages, financial, etc., it is important to remember that this list represents the user's perception. No attempt was made to change the data to fit current DSS definitions.

reinforce the concept that the DSS was a personalized tool and not prescribable by others. Specific notable comments on DSSs include:

"I wouldn't want a DSS because I'd probably play with it instead of using it,"

"I wouldn't use a DSS (DBMS reference) because there's no time to get organized,"

"the company is holding back the use of DSSs,"

"the corporate structure stifles the introduction and use of DSSs."

Hard copy, paper printouts seem to be the lifeblood of corporate decision making. With time to make decisions relatively long there is little pressure to change the status quo by introducing DSS capabilities. Until the high level officials realize how their effectiveness can be increased through the use of these new concepts the introduction and acceptance of DSSs will be slow.

A final comment on Figure V-5. How many of the items were generated by the interviewer vice the interviewee? The corporate officials visited are individually, and as a group, very intelligent, knowledgeable about their companies, and relatively open minded. They are more than capable of generating such a list, and in fact did so with very little input from the author.

This interview data provides a basis for suggesting additional production rules (IF CONDITION-->THEN ACTION) for

the DECAIDS model. The following were directly developed from the interview data and generally grouped in categories of Group, Environment, Task, Structure, Individual, Technology and DSS capabilities.

Certainty factors, associated probability of the occurence of particular conditions, are included in some of the structure and DSS production rules only to exemplify their application in this methodology. These factors may be included or omitted in any production as deemed appropriate by the system designer and, in either case, the AI capability of DECAIDS will operate correctly.

GROUP

IF GROUP is small, formal, geographically dispersed,
AND TECHNOLOGY is high,
THEN DSS capabilities should include automatic message handling systems, time-sharing, inter-active displays, data networks, simulations, and sensitivity analyses models.

IF GROUP interaction is high,
AND the TASK IS non-structured,
AND the ENVIRONMENT is dynamic,
THEN appropriate DSS capabilities include large scale displays, automatic message handling, and individual I/O devices.

IF GROUP is formal and makes decisions,
THEN DSS capabilities should include formalized decision aids.

ENVIRONMENT

IF ENVIRONMENT is dynamic,
AND TECHNOLOGY is high,
THEN DSS capabilities should include
teleprocessing,
real-time data base access.

IF ENVIRONMENT is dynamic,
AND includes planning,
THEN DSS capabilities may include on-line
graphic displays, crt I/O devices and
complex DBMSs.

IF ENVIRONMENT includes high competition,
and complex sets of regulations,
THEN DSS capabilities could include data
base alerters, on-line data
retrievals, cost accounting systems
to produce ad-hoc reports.

TASK

IF TASK includes MIS and general information services,
AND the ENVIRONMENT is mostly planning,
AND the GROUP makes decisions,
THEN DSS capabilities should include large scale displays, and PERT/CPM models.

IF the TASK consists of labor management negotiations,
OR international policy communication,
AND GROUPs are involved,
THEN DSS capabilities should include quantitative models, graphic displays, interactive and real-time computer support, multi-variable analysis (at least multiple-regression analysis and polynomial curve fitting) and bar graphs.
The DSS called POLICY provides these capabilities.

(Hammond, 1979:80-82)

IF TASK is financial management,
  AND STRUCTURE is highly variable,
THEN DSS capabilities should include
  models to track and allocate funds,
  produce investment plans, and
  maintain budget status.

IF the TASK includes financial
  management,
THEN appropriate DSS capabilities include
  financial models, economic models,
  forecasts, prime-rate data bases,
  trade reports, budgets, data on
  competition, and on-line query
  capability.

IF the TASK includes management of
  business data processing,
  AND the INDIVIDUAL is technically
    qualified,
THEN appropriate DSS capabilities include
  on-line, batch, crt and graphics
  display, performance criteria model,
  history selection ability, vendor
  selection ability, vendor selection
  and bid preparation models.

IF TASK involves transportation of
products to multiple points,
THEN DSS capabilities may include
operations research models.

IF TASK is very structured,
THEN DSS capabilities can include
off-line batch processing, routine
detailed and summary reports.

STRUCTURE

IF the STRUCTURE is matrix,
AND TECHNOLOGY is high,
AND TASK is structured,
THEN DSS capabilities should include audio I/O, real-time forecasting models, DBMS, and data networks.

IF the STRUCTURE includes a high level steering committee assigned to the MIS function,
THEN the probability of success is high.

IF the STRUCTURE rank of the MIS chief is executive,
THEN the probability of a successful MIS is near zero.

IF the STRUCTURE is decentralized,
THEN there is an increased involvement and motivation of profit center managers.

IF the STRUCTURE is bureaucratic,
THEN DSS capabilities will be identified and used at the mid (.5) or low (.8) organization management levels.

IF the STRUCTURE is adaptive,
THEN DSS capabilities will be used at the upper (.6) and mid (.8) organization levels.

IF the STRUCTURE is highly decentralized, AND TECHNOLOGY is high,
THEN DSS capabilities should include automatic message handling (.8), data base alerters (.8), and data base management systems (.8).

IF the STRUCTURE requires a high degree of control and feedback,
THEN DSS capabilities might include real-time computer systems, time-sharing, ad hoc display request menus, war-room information centers, and high speed communications.

IF the STRUCTURE depends on rapid changes,
THEN DSS capabilities should include real-time systems, data base alerters, DBMS, and forecasting models.

IF the STRUCTURE is relatively stable,
AND the LEADER directly accesses information,
THEN DSS capabilities should include natural languages, on-line systems, time sharing, individual terminals, and priority schemes for access to the data.

IF the STRUCTURE is decentralized,
THEN DSS capabilities should include redundant and lateral communication means.

INDIVIDUAL

IF INDIVIDUAL needs to do a great deal of planning, communicating and reviewing accomplishments,
THEN DSS capabilities should include DBMS, "what-if" models, message handling systems, on-line machines.

IF the INDIVIDUAL deals with physical distribution and transportation,
AND the ENVIRONMENT is relatively stable,
THEN appropriate DSS capabilities include network models, batch processing and periodic printed reports.

IF INDIVIDUAL does massive review of accomplishments,
AND ENVIRONMENT is dynamic,
AND TASK time is short,
THEN DSS capabilities may include closed circuit television to the information center, real-time communications and displays.

IF INDIVIDUAL is highly technical,
AND TECHNOLOGY is high,
THEN DSS capabilities could include
knowledge acquisition systems,
natural languages, hybrid computers
and simulations.

IF the INDIVIDUAL deals with physical
distribution and transportation,
AND the ENVIRONMENT is relatively
stable,
THEN appropriate DSS capabilities include
network models, batch processing and
periodic printed reports.

TECHNOLOGY

IF TECHNOLOGY is high,
AND GROUP is small, formal, geographically dispersed,
THEN DSS capabilities could include automatic message handling systems, time-sharing, interactive displays, data networds, simulation and sensitivity analysis models.

IF TECHNOLOGY includes modern techniques and machines
AND the STRUCTURE is matrix,
AND the TASK is structured,
THEN DSS capabilities could include audio input/output, real-time forecasting models, data base management systems and data networks.

IF TECHNOLOGY is modern and includes large
scale computers,
AND the STRUCTURE is highly decentralized,
THEN DSS capabilities could include
automatic message handling systems,
data base alerters, and data base
management systems.

IF TECHNOLOGY includes advanced computer
techniques,
AND the INDIVIDUAL is highly technical,
THEN DSS capabilities could include
knowledge acquisition systems,
natural languages, hybrid computer systems
and simulations.

DSS CAPABILITIES

IF DSS capability is corporate model,
THEN INDIVIDUAL may be vice-president (.9),
AND ENVIRONMENT is medium dynamic (.6),
AND TASK is MIS.

IF DSS capability is data analysis, forecasting and planning models,
THEN TECHNOLOGY level is high (1.0),
AND INDIVIDUAL skills are high (.7),
AND GROUP plans (.6) and makes decisions (.8).

IF DSS capabilities include "what if" games and financial analysis models,
THEN STRUCTURE is line/staff (.2),
AND INDIVIDUAL has technical background (.6).

IF DSS capabilities include tax models
  and sophisticated DBMS applications,
THEN INDIVIDUAL is tax oriented or a
  C.P.A. (.7),
  AND TECHNOLOGY is high (.8).

The DSS capability rules indicate how the DSS capabilities can be used as the CONDITIONS part of the production rule and the GETSIT variables become the ACTION set. This is an example of how the knowledge base can be designed to effect the transfer of technology.

Summary

The interview data were personally collected over a five-month period using a structured interview methodology. Analysis of the data generally supports the literature except in the area of informal groups. The relatively high level official interviewed and the small sample may explain this divergence.

Analysis of the interview data provided some insight concerning corporate management at two levels. More importantly, however, the analysis resulted in determining representative DSS capabilities for these management levels. Several production rules were derived from the data and are proposed as new knowledge available to enrich the DECAIDS knowledge base.

CHAPTER VI

DECAIDS[1]

Introduction

A prototype decision aid system, DECAIDS, was constructed using the Stanford University EMYCIN production rule structure. DECAIDS demonstrates the use of production rules to support the relatively unstructured interactions experienced by high level managers. A discussion of knowledge based systems and technological requirements for such a system is included.

The identification, development and implementation of DECAIDS was accomplished concurrent with the literature search of Chapter III and the on-site data collection of Chapter IV. The DECAIDS knowledge base does not currently include all of the production rules discussed in this research because of this parallel effort. Details are provided for knowledge acquisition and entry. A tutorial (Appendix B) discusses in detail how to develop a backward-chaining, goal-seeking knowledge base system, such as DECAIDS.

Overview

A prototype decision aid production rule system, DECAIDS, was developed using the Stanford University EMYCIN inference engine as its framework. DECAIDS uses an

[1]From the combined research of Roland, Buscemi and Masica.

artificial intelligence (AI) methodology to make recommendations in selection of decision support system capabilities based on the user's definition of specific organizational situations. The purpose of DECAIDS is to provide recommended decision support system capabilities during an interactive consultation. During this session, specific information is requested from the system user, or users, concerning their organization's task, technology, environment, and structure characteristics. This information is then used to invoke DECAIDS producttion rules which provide resultant recommendations. Future enhancements of this prototype system will include the variables group and individual.

A detailed description of how to use DECAIDS is provided in Appendix C, DECAIDS User Procedures. It is immediately followed by a sample consultation (Appendix D). Frequent reference to these appendices is recommended during the reading of this chapter to understand how the technical detail was actually implemented - to "see" the end result.

An important consideration in the use of AI is that a computer program (software) is used to produce "behavior" similar to that of a human. Generally, the problems posed to AI are not those for which specific algorithms can be written. For instance, a manager probably could not explain, algorithmically, how he arrived at a particular decision. He uses a myriad of facts, procedures, and experiences to tell

him what to do during certain circumstances and these factors are used to produce a decision. EMYCIN, was developed with the assumption that a computer would use the same data that the human used in an analogous manner. DECAIDS, through EMYCIN, provides a method to weigh conflicting information, calculating how much information is sufficient to achieve a recommendation. Concurrently those cases where insufficient information is available to arrive at an acceptable solution are also identified. The AI program parallels these human processes as closely as possible in order to produce realistic results (Scott, 1979).

The EMYCIN structure is written in a computer language called INTERLISP. This language provides an excellent basis for AI systems because the information in the knowledge base is grouped into lists manipulated by the various INTERLISP functions. This chapter provides the background and concepts required to design, implement, and operate an artificial intelligence knowledge based system.

The "Essential" MYCIN (EMYCIN) inference, production rule, engine is the programming vehicle used to accomplish deductions and produce conclusions in DECAIDS. The name MYCIN was given to the production rule program which was first concerned with infectious blood diseases because many medicines ended with the suffix "-mycin." EMYCIN is an extension of the original structure to other domains. The term "inference engine" refers to the concept of EMYCIN

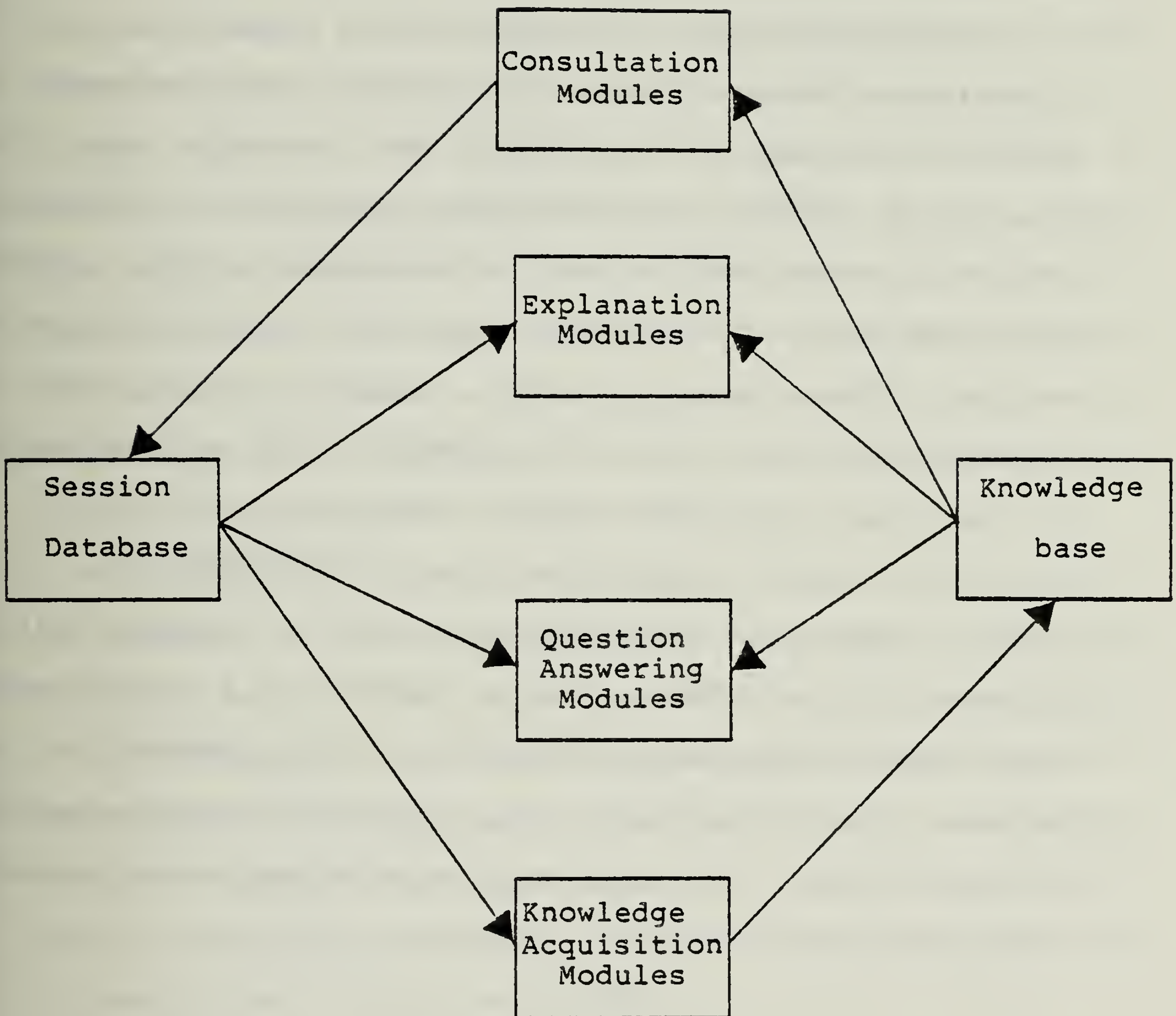


Figure VI-1. Inference Engine Modules.

being a soft machine which produces inferences (Scott, 1979). The inference engine modules are depicted in Figure VI-1.

Interaction with the system is provided by the consultation module. Three other system utility programs or modules are used for extending the knowledge base (the acquisition module), for providing reasons for a conclusion (the explanation module), and for answering natural language questions about the knowledge base (the question-answering module). These modules occupy a total of 130,000 words of nonshared code, are written in INTERLISP, and run fast enough for real-time interaction (Davis, 1977:15-43).

The basic structure of INTERLISP is the symbolic-expression (s-expression) which is called a list of elements. These elements may be numbers of function names. This format s-expressions can be readily adapted to the n-tuple concept described in the predicate calculus section of this study. The following example has three elements (Teitelman, 1974:53).

(PLUS 3.14 2.71)[1]

PLUS is the addition function standing before the two arguments, 3.14 and 2.71, which are to be acted upon. This example also demonstrates the prefix notation which is used in INTERLISP (i.e., the function always precedes the arguments).

---

[1]The parentheses are required for all references to INTERLISP.

MYCIN uses INTERLISP to provide the inference engine (inference manipulation) for the prototype managerial decision aiding system, DECAIDS. INTERLISP is a relatively easy language to learn and use because it is constructed of a simple syntax. It requires no previous knowledge of high-level computer languages such as FORTRAN or PL/1. There are approximately forty common functions in INTERLISP. Approximately one-half of these are highly mnemonic arithmetic operations, while the remaining functions perform other operations required for list processing and symbol manipulation (Winston, 1977:263-285).

The current DECAIDS domain specific knowledge (Appendix E) consists of less than 50 production rules. Each rule contains, as mentioned, a premise and an action (IF CONDITION -->THEN ACTION). The premise is a Boolean combination of predicate functions on associative triples with each premise clause containing a predicate function, and object (context), and an attribute (parameter) value. An example of a clause in English is:

"If: The structure of organization is line,"

and in INTERLISP syntax is,

"($AND (SAME CNTXT STRUCTURE LINE))"

To explain the above statement the idea of the triple (predicate, object, attribute) is essential. (SAME CNTXT STRUCTURE LINE) is such a triple, where SAME is the predicate, CNTXT STRUCTURE is the object, and LINE is the

attribute. The execution of the triple portion of the statement will imply that the context structure is now the same as line, in other words line has been added to the system context structure. The $AND is not used until the ACTION portion of the statement is added. The "then" part of the rule is the conclusion statement. Appendix F contains a listing of the standard predicate functions used in premise and conclusion statements. The premises are evaluated in INTERLISP to test for their validity and the conclusion action performed if "true" is the premise value. Known conditions are saved in the "session data base" by a rule adding that condition (Davis, 1977).

Knowledge Base

The knowledge base, for an artificial intelligence program, is the data base supplied by an "expert" and operated on by the production system. This knowledge base consists of an ordered string, or strings, of replacement rules. Designing and implementing a knowledge base requires the answers to some general problem-solving questions:

> What kinds of data are required? (specific facts or ideas); how should the knowledge be represented? Should the system query the user or vice versa? (EMYCIN and hence, DECAIDS, queries the user to derive inferences.)

> How much knowledge is required to cover the subject? (Specific, scientific subjects lend themselves far more readily to quantification than do more subjective domains.) What is the required information?

Finally, a knowledge base must be modeled and the tree of subject entities (contexts) arranged so that the questions asked about the domain are contextually sensible, that is, have some direction. It serves little purpose for the program to ask questions that have no direction. The knowledge base's context tree must provide this understanding to the consultation-recommendation session. The questions asked during the consultation must be asked in a logical order to fill in the knowledge base. This can be partially accomplished by arranging the queries in an order that makes the session flow in a smooth manner. When the entire context tree has been traversed, inferences are produced via the system's production rules.

The EMYCIN system provides a framework for building consultation programs in various fields. The domain independent components of production rule systems and backward-chaining mechanisms manipulate the information in the knowledge base. More specifically, EMYCIN (and thus DECAIDS) uses an evolving knowledge base composed of declared parameters and rules for concluding goals.

The knowledge base contained in DECAIDS is designed to support a prototype managerial decision aiding tool. While the recommendations rendered by DECAIDS are straightforward, it must be remembered that the primary goal of this research was to demonstrate a capability of designing and implementing a decision support system based on the use of AI technology. While previous AI research programs have been directed toward more structured applications, the current research investigates an area which is relatively unstructured and very subjective. Previous applications, for example, the subject of blood chemistry, result in many specific statements and rules relative to the chemical conditions affecting a person's health. Managerial decisions are, by comparison, much more difficult to describe.

Two types of elements are contained in the knowledge base. These elements are the rules and parameters used by the DECAIDS inference engines to support the various recommendations. The rules are the sentences, IF CONDITION -->THEN ACTION statements, which imply the value of parameters. The specific syntax for the rules and parameters are explained and discussed later. The rules are the statements which ask for the needed values and produce the recommendations. These questions may be asked either explicitly by the system user or implicitly from the system itself.

The parameters are the nouns used in the sentences. One or more of these parameters will be identified as the root parameter(s) in the root or base context. The remainder of the parameters are used to help define and determine a value for this root parameter(s). Specific definitions and instructions concerning these properties are contained in the DECAIDS Tutorial (Appendix B).

The prototype system (DECAIDS) identifies key parameters affecting organizational managers and the decisions which they must make. More specifically DECAIDS attempts to "quantify" these parameters in order to deduce recommendations concerning appropriate DSS capabilities. These recommendations are based upon organizational characteristics described by the user.

The current DECAIDS knowledge base was developed in parallel with the literature search of Chapter III and on-site data collection of Chapter IV. As such the knowledge base is not considered comprehensive; rather it is a skeleton which can be further expanded by subsequent updating and research. DECAIDS' current knowledge base consists of forty-one rules and twenty-three parameters (see Appendix E and G). Figure IV-2 represents the current DECAIDS structure.

The knowledge base structure (Figure VI-2) has ORGANIZATION as the root context. This context is defined by the organization's structure and environment. The following

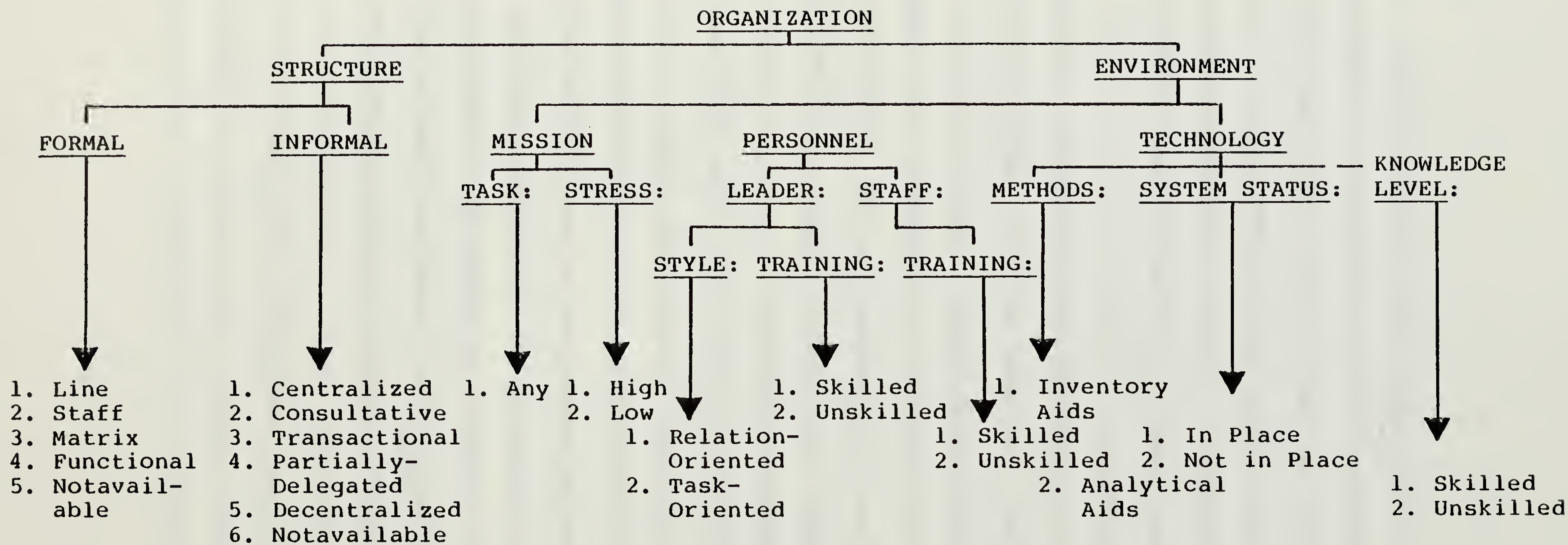


Figure VI-2. DECAIDS Knowledge Base.

sections of this chapter describe the DECAIDS parameters and the recommendations which are reached during the interactive consultative session(s). In the following discussions, DECAIDS parameters are indicated in capital letters.

The organizational structure is subdivided into the formal and informal structure. The formal structure (FORMAL) involves the official patterns of authority and the location of responsibility and accountability within the organization. Public and private sector usage has resulted in the identification of four basic formal structures. These four categories define the different lines of command, control, advisory, and functional relationships. The four basic formal structures used in DECAIDS are: line, line and staff (called staff), function, and project manager (called matrix).

The informal structure (INFORMAL) describes the system of transactions, dynamic and interpersonal, which occur within an organization. These informal processes, patterns, and relationships develop quite naturally as organizational personnel interact to handle the problems and requirements of their roles in their own particular styles. While the organization's formal structure establishes the division of labor within the organization, the informal structure identifies the reality of organizational behavior and performance based upon the individuals involved.

The informal structures as used in DECAIDS are: centralized, consultative, transactional, parially-delegated, and decentralized. A centralized structure employs a focused flow of authority to a single source at the top of the hierarchy. Consultative-type informal structures maximize patterns of central control, but encourage vertical, upward communication of advice/guidance from the professional staff. Open communication, deliberation, and negotiation, not only vertically among heirarchical levels but laterally among levels is highly encouraged by transactional structures. This type structure does not preclude the ultimate decision remaining with the high levels of the hierarchy. Another form of informal structure promoting management by negotiation is the partially-delegated structure. This system distributes authority among the professional staff while increasing the need for coordination of effort. Under this arrangement, staff personnel have authority to develop action alternatives with top management retaining the right to approve, reject, or modify these options. Finally, the decentralized structure uses a high degree of delegation and dispersal of decision making authority to lower levels of the higher hierarchy.

Formal and informal structures represent the theoretical and realistic arrangement of organizations, respectively. Formal structure defines a set of decision methods and procedures designed by management to optimize the performance

of the organization. The formal structure that is chosen reflects past management experience and is based upon expected personnel configurations. The informal structure defines the actual decision methods and dynamic problem-solving processes that are used to motivate organizational performance.

In reality, these informal structures may exist in a myriad of combinations and variations. DECAIDS uses them individually and independent of one another. This system also offers the user additional choices of declaring both formal and/or informal as unknown, translated in DECAIDS as not available. If this option is used, the program contains production rules which will return suggested configurations for formal and informal structures.

Another parameter affecting organizations is the environment in which the organization must operate. There are three basic factors which make up this environment. They may be described as: the task or mission to be accomplished, the personnel, individuals and groups, required to perform the mission, and the technology available to perform the mission.

The model defines the task in terms of problem definition (PROBDEF) and stress level (STRESS). The user is asked to define the task in terms of problem definition, either clearly defined or ambiguous. Stress is defined as high, low, or unknown.

Personnel environment is divided into two categories concerning the leader and staff. The system currently contains only two parameters related to the leader. These are the leader's style (STYLE) and his level of training (LEADER-TRAINING). Leader style is defined as either relation-oriented or task-oriented. Relation-oriented refers to the leader who gives little direction to his staff, encourages them to actively participate in setting decision-making parameters, and values the development of personnel responsibility.

Conversely, task-oriented leaders are defined as those who prefer far more centralization or consultative structure and are less concerned with the development of individual responsibility in the decision-making policy. Leader-training relates to the level of training in the use of the computerized technical aids which the leader currently possesses and is defined as either skilled, unskilled, or unknown.

The staff environment is currently defined by only one parameter, staff-training (STFFTRG). This parameter relates to the staff's level of training in computerized technical aids and is either skilled, unskilled, or unknown.

The available technology relates to three parameters: computer system status (SYSSTAT), the technical knowledge level required to perform the task, and the purpose of the system's use (METHODS). The first parameter, computer system

status, refers to the implementation or operational status of the organization's computer assets. The only alternatives currently offered are: yes, an operational system is in existence, or no, there is none in operation. The alternatives allowed for knowledge level are skilled or unskilled. The other parameter used to define technological environment deals with the use of the system. The current accepted responses are inventory aids or analytical aids. Inventory aids is used in a generic sense to refer to administrative type uses of technology while analytical aids are those which concern scientific applications.

DECAIDS System Goals

The system is currently designed to support three goal parameters. These goals are decision aid capabilities (DECAIDS), formal structure (FORSTRUC), and informal structure (UNSTRUC). Successful inference of the first parameter, DECAIDS, is the primary goal of the current program. The interactive session between the system and user is aimed at deducing appropriate decision aid capabilities based on the production rules which reflect the user's decision making situation.

DECAIDS is composed of four parameters that define various capabilities of computer decision aids (Figure VI-3). The current definition includes the recommended type of computer system (TYPSYS), output devices (OUTPUT), computer

DECISION AID SYSTEM (DECAIDS) CAPABILITIES

TYPSYS:	OUTPUT	INSTALL:	TRG:
1. Real-time	1. Individual-terminals	1. Pyramidal	1. Train existing staff
2. Non real-time	2. Large screen displays	2. Divisional	2. Hire specialists
3. Notavailable			3. Do not hire specialists

Figure VI-3. DECAIDS Options.

installation arrangement (INSTALL), and the best training/assistance alternatives for successful implementation (TRG). The current type systems recommended are real-time and non real-time. The ouput devices are either individual terminals or large screen displays. The possible installations are divisional and pyramidal. Divisional installation places authority in each division for independent systems while pyramidal installation places authority at the top of one super-system above all divisions. The final parameter reflects the training needed or assistance required by the organization in order to implement a computer based decision aiding system.

The two other goal parameters, referring to formal and informal organization structure, are invoked when the user responds that either or both of these structure are not available. When this answer is indicated, production rules for FORSTRUC and/or UNKSTRUC result in the recommendations for the use of either line and/or centralized structures are made.

Acquiring New Knowledge

Since any domain of information can be expected to change, a capability to add and delete knowledge must be provided. The updating of an evolving knowledge base is necessary to give the subject system acceptability and recognized competence (Williams, 1978:3). Appendix E,

DECAIDS Production Rules, is a listing of the current DECAIDS knowledge base in a format understood by the EMYCIN system.

The addition of knowledge to DECAIDS is accomplished by introducing production rules using the INTERLISP syntax. DECAIDS scans new rules provided by the expert to find key words which indicate the appropriate predicate functions and a template, function-context-parameter-value tuple, to be retrieved. Values provided for the parameters must be included in the list of permitted or expected values for that parameter. Upon completion of the parse of the rule, the new rule is added to the appropriate list of relevant rules of the same rule group (Davis, 1977:25).

When adding new rules, direct contradictions should be avoided. While the certainty factor computations will provide a resolution, the strength of the consultation recommendation will be weakened by contradicting rules. New values and parameters must also be updated throughout the information structure of the system. While new rules may be added without regard for deleting old ones (only the true, relevant rules will be executed), parameter values must be kept abreast of current technology. Finally, the additions of not just a single rule but the addition of an entire concept must be carefully planned when being added to a knowledge base. A single rule is easily expressed and added to the program. However, a set of rules, stated in the backward-chaining, goal-directed manner must be carefully

organized. Due care must be exercised in writing a logical ordering of rules to achieve a complex concept or goal. Written first in the system writer's natural language (i.e., English) the question asked of the user (or implicitly of the system) will be the rule concluding the parameter values.

The following is an example of the process used for knowledge acquisition.

1. A system designer has been tasked to accept ideas from an organizational theorist and information analyst and to produce production rules leading to a recommendation concerning decision support system utilization.

2. Based on the system designer's knowledge it has been decided that STRUCTURE, the name of an organization variable may have one of two possible organizational types: LINE or MATRIX. STRUCTURE, LINE and MATRIX will be used by the system designer as parameters in the knowledge base. LINE and MATRIX are values for the variable called STRUCTURE.

3. It has further been decided by the system designer that if STRUCTURE has the value of LINE, then the organization is recommended to use a large computer, graphic display, and batch processing capabilities.

4. Accordingly, the system designer decides to declare SIZE (of the computer), TYPE (of display), and MODE (of processing) as parameters with values of large or small printer or graphic, and interactive or batch, respectively.

5. The system designer next verbalizes a premise:

   If the structure is line

   (and, next he verbalizes an action)

   Then strongly suggest a large computer be used

   (cf .8)

   strongly suggest graphic terminals be used

   (cf .8),

   strongly suggest batch processing be used

   (cf .8).

6. Finally, the rule is written in INTERLISP syntax:

```
($AND (SAME CNTXT STRUCTURE LINE)
(DO-ALL (CONCLUDES CNTXT SIZE LARGE TALLY 800))
        (CONCLUDE CNTXT TYPE GRAPHIC TALLY 800))
        (CONCLUDE CNTXT MODE BATCH TALLY 800))
```

The phrase "TALLY 800" is the required certainty factor syntax.

The design of the new rule is now complete. At this point the "expert" must interface with the DECAIDS knowledge base in order to enter this new data. Appendix I, DECAIDS Knowledge Acquisition Procedures, is a step-by-step account of how knowledge can be added to the system. Appendix G, the DECAIDS Parameter List, and Appendix H, Additional EMYCIN/DECAIDS Parameter Properties, are provided as logical adjuncts to the modification procedures.

The current domain of information is described by a single context and related parameters. It is intended to be

a prototype domain for a decision aiding support system and an example of how to structure a knowledge base. It is expected that the knowledge base will be extended to include a more complex context tree supporting a far more thorough treatise of the decision aiding support process. The following information is directed toward the individual who will extend the current knowledge base.

Prior to doing any coding or entering of any rules or parameters, it is strongly advised (cf 1.0) that the system goal(s) be explicitly defined. This means not only deciding that the system is to provide some form of advice but, more specifically, to write out the natural (i.e., English) language questions which will be used to trace parameter values. Entering rules and parameters into the DECAIDS knowledge base is not unlike any other high-level-language coding where a flowchart of operations and data manipulation is appropriate. A system designer is reminded that the primary emphasis for extending a knowledge base is a consistent line of questions to be asked in order to trace parameter values. Eliminating or ignoring the requirement to specify the questions to be asked can only lead to confusion.

When to define a context or multiple contexts may present the system designer with some confusion. It is recommended that the designer review the notes on backward-chaining and the concept of inferences. This information will provide the necessary background for

constructing rules which terminate in the determination of values for parameters.

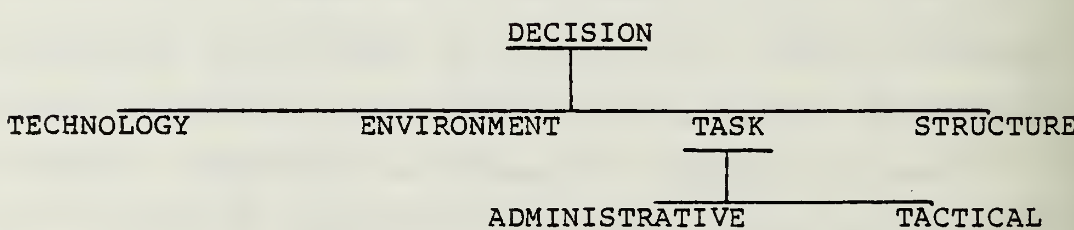
Most often a single context will suffice for a small to medium size knowledge base. However, to fully describe the management decision aiding characteristics about some subject (i.e., financial control, major procurement systems, etc.) may require a more complete context tree. The subjects that become contexts are those that cover areas of information which will always, or nearly always, be used to define the value of the root, goal-parameters. The infectious blood disease domain of MYCIN, for example, is described by the following contexts:

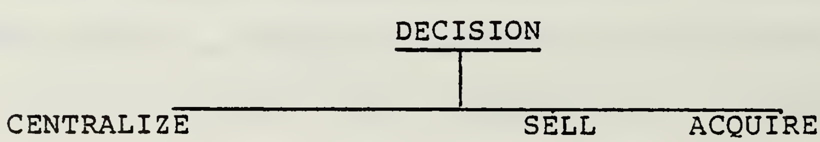
PATIENT

CULTURE

ORGANISM

Each of these contexts has multiple parameters leading to the goal-parameter(s) values. The management domain might include contexts such as:





The selection of contexts is strictly the system designer's choice. The system is best kept as uncomplicated as the subject will permit. Rules and parameters will be grouped by the RULEGROUP and PROPGROUP properties, respectively, and selected by the rule interpreter/monitor for use in the program. The designer's responsibility is to design a logical set of backward-chaining rules, to define all rules and parameters, and to structure the context tree.

Technological Description

EMYCIN consists of several computer software modules which, as a group, provide the structure to build knowledge based production systems. INTERLISP is the computer language used to build EMYCIN. It is an interactive capability of the LISP programming language and is used for two basic reasons. LISP has proven to be very capable of managing data structures which are primarily list oriented, such as the CONDITION ---> ACTION forms of production systems. INTERLISP provides the interactive capability to modify, create and otherwise use the LISP language thereby facilitating the human-system interface.

The EMYCIN structure is an evolving project under the direction of Prof. Feigenbaum at Stanford University, Palo Alto, California. Technical considerations were such that EMYCIN could not accommodate the DECAIDS model with Stanford computer resources; therefore, the EMYCIN software was

electronically moved from Stanford to the University of Southern California (USC). DECAIDS was built and runs using USC computer resources.

The EMYCIN structure requires approximately 130,000 words of computer memory if all modules are included at one time. A modular construction permits the use of much less computer space at any given time as all modules are not needed simultaneously. For instance, the editing function of INTERLISP is not required when running a consultation.

Hardware facilities used at the USC include a Digital Equipment Corporation large scale computer called a KL2040 located at the USC Information Science Institute. Local reference to the hardware system is the ISI-system E or ISIE. ISIE is a time-share system and facilitates the on-line real-time interaction requirement of DECAIDS. TOPS-20 is the title of the KL2040 operating system. The availability of virtual memory (a large disk system actually) enhances the growth and use of the knowledge base.

Summary

DECAIDS is proposed as a prototype decision aiding system. It explores the use of artificial intelligence techniques to effectively model manager's perspectives on their organization situations. The immediate recommendation from DECAIDS includes suggested DSS capabilities.

There are no technical constraints (beyond the computer memory size) to the use of such an AI methodology to model an organization. Enhancement of the knowledge base can be done by managers or other non-technical individuals by following the appendices provided.

DECAIDS is currently available at the USC/ISIE facility. It may be used to test, investigate, become acquainted with or modify the knowledge base. MYCIN may also be made available, if desired. The author will provide access on a case by case basis.

CHAPTER VII

CONCLUSIONS

The benefits of interdisciplinary coorperation for studying and understanding organizational processes is being recognized by managers, technologists and academicians. In the development of a computer model to facilitate the transfer of decision support system methodologies into managerial decision making areas, the concepts from the areas of organizational theory and behavior, decision science, computer science and industrial engineering are synthesized. Benefits that may accrue from this research have yet to be realized. Before outlining the implications for management and the opportunities for research, the purpose of the research as well as the research findings must be reiterated as a foundation for recommendations.

Research Purpose and Findings

The basic research objective was to determine whether a computer model could be designed and operationalized to effect technology transfer pertaining to organization and management. The logic that led to that research objective includes the following:

- Organizational processes are complex and difficult to describe let alone model with accuracy, yet in order to design and implement information systems, and in

particular decision support systems, the processes must be identified.

- A considerable amount of research has been done on decision aiding methods and technologies, however, no common means of cross-communicating the results of the work or the needs of the decision maker exists.
- A plethora of variables has been used to describe how organizations operate. No quantifiable works are available which suggest what or how many variables are necessary or sufficient for such a description.
- Contingency theorists propose modeling organizations by identifying contingent IF-THEN (CONDITION --> ACTION) relationships among a set (or sets) of variables. Operationalizing such a model without appropriate technical capabilities is impractical.
- Therefore, if appropriate organizational variables could be selected and a methodology to efficiently mechanize IF-THEN relationships developed, a structure could be designed to model the organizational process and predict relevant decision support capabilities.

The results of the research reported here show that it is possible to design and develop a model, based on artificial intelligence concepts, which is capable of using

contingent organizational relationships with a resultant prescription for decision aiding capabilities.

A thorough review of the literature provided strong support for the sufficiency of using the six variables, group, environment, task, structure, individual and technology (referred to as GETSIT) to describe an organization. The review also provided a group of DSS capabilities that could be contingently related to the variables, individually or in combination. Development of various contingent relationships among variables was another result of the review.

In order to verify the use of the six variables used to describe a generic organization a structured interview was developed for conducting personal interviews with corporate managers. The results of 43 separate interviews strongly support the use of the GETSIT to model an organization. Further results of the interviews show a considerable degree of comfort for managers to use contingent IF-THEN (CONDITION -->ACTION) relationships to describe organizational processes.

A concurrent review of the technical literature (computer and decision science) resulted in identification of knowledge engineering techniques that could be used to directly model the contingent relationships developed from the literature and corporate interviews. The EMYCIN production rule structure was used to develop a model called

DECAIDS (from DECision AIDS) which prescribes capabilities of relevant decision support systems based on the characteristics of certain organization variables (GETSIT) which affect the decision maker. DECAIDS is designed for managers or military commanders to use in identifying decision aid capabilities which could support their medium and long range decision making requirements. Concurrently DECAIDS can be used by DSS researchers to identify managers' needs to better direct research efforts. The results of this research support the propositions that:

- AI technology is suitable for modeling a complex organization process,
- The GETSIT variables are sufficient to describe an organization, and
- Characteristics of organization variables and DSS capabilities are symbiotically related in that a major change in a characteristic could indicate a corresponding change in the capability, and vice versa.

Implementation of DECAIDS strongly suggests the validity of using an EMYCIN type structure to operationalize the interactivity of complex organizations. While introduced only as a prototype, DECAIDS represents a first step toward having a capability to model managerial situations with an ease not heretofore possible.

The use of this capability does allow sensitivity testing, that is, if the user wishes to vary the contingent relations of the variables, corresponding changes will result in the prescribed DSS capabilities. The converse is also true. It is possible to structure the model such that by changing the DSS capabilities, variances in suggested organization variable characteristics will result.

Research Opportunities

The implications of the results of this research include some research opportunities reported here. Developed as a prototype, DECAIDS is both an automated model and a methodology for describing and studying complex organizational interactions. Prescriptions which result from the model's deductive inferences consist of a group of capabilities which should be considered for inclusion in future DSSs. As the organization changes or new DSS capabilities are introduced the model's knowledge base can be easily updated by either a manager or technologist.

A next step for DECAIDS is validation. As a prototype, this system performs as expected, however, further acquisition of expert knowledge is necessary to analyze the model. While results to date have been consistent, the current knowledge base was acquired over a wide range of sources. Selection and in-depth study of a specific organization is suggested as a research topic. The

development of appropriate contingencies, their translation into IF CONDITION-->THEN ACTION production rules, and implementation of a model which proved satisfactory for one organization would provide a basis for initial validation.

A second area of research is investigation of the DECAIDS knowledge base and its extension to current knowledge. Any model, manual or automated, must have current knowledge to remain useful. DECAIDS is no exception. Continued acquisition or expert knowledge is necessary to enhance the model's prescriptive ability. This should not prove difficult in that once an adequate knowledge base is established the continued update will be relatively infrequent. Neither technologies nor organizations change fast enough to require real-time updating, therefore, a reasonable capability once established will not be difficult to maintain. Extending the knowledge is simple in the mechanical sense using the appendices included in this work. Obtaining and building additional, relevant, production rules and including them in a logical fashion will require a substantial research effort.

Another area for future research is to investigate the use of other artificial intelligence structures for implementing similar models. This work has clearly established the feasibility of using AI techniques, however the EMYCIN structure, used to create DECAIDS, is not the only production system in existence. Continued research is

suggested concerning the availability and applicability of other systems. For example, EMYCIN requires a large computer to conduct sessions with the user. many organizations are investing in mini-computers and perhaps there is a suitable system that can operate on a smaller machine.

Finally, it has been demonstrated that complex organization interactions may be decomposed by identifying contingent relationships among selected organizational variables. Stated in the form IF CONDITION-->THEN ACTION these contingent relationships can be modeled using the artificial intelligence constructs of production systems. The result is a capability to readily model organizational concepts.

For the academician concerned with organization and management theory, organization behavior or information system/DSS design, this methodology represents a tool previously unavailable. Research in operationalization and testing of various behavior models, for example, is relatively simple using techniques of the EMYCIN structure and the DECAIDS system.

Whatever research is undertaken on the basis of this study, it should not be conducted in isolation within one discipline if it is to be both successful and contribute to the technology transfer process. A joint effort consisting of members representing management science, management information systems, organizational development (and

behavior), and management in general is suggested. Short of such a group at least some experience in these areas or knowledgeable colleagues are mandatory.

The DECAIDS concept is a new application of current research and provides a bridge between the worlds of technology and management decision making. It is a tool for managers to use in exploring alternative capabilities which could assist them in the decision process. Concurrently, technologists are provided a means of viewing and understanding management problems and needs.

Application of the principals of AI to the study of organizations has not been the subject of many studies. As an understanding evolves between members of these two disciplines meaningful communications can begin. Each has much to offer and it is hoped that this work can be the catalyst for initiating such dialogue.

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APPENDIX A

A MODEL FOR TECHNOLOGY TRANSFER

Structured Interview

DECAIDS

Ronald J. Roland
Code 52RL
Naval Postgraduate School
Monterey CA 93940
(408) 646-2269/2449

<u>Interview Format</u>

NAME OF FIRM	____________
TYPE OF BUSINESS	____________
PERSON INTERVIEWED	____________
POSITION IN FIRM	____________
INTERVIEW DATE	____________

INTRODUCTION TO THE STUDY - PURPOSE.

GROUP

1. FORMAL

   a. To what formal groups do you belong within the firm?

   b. Do you perform any decision making functions in concert with a formal group?

      If yes, determine group

      size

      members status in firm

      how the group operates, e.g. democratic, how often it meets, etc.

      permanency of group.

   c. Describe aids the group uses to assist decision making.

      Specific characteristics.

2. INFORMAL

   a. Identify the informal groups with which you are associated with respect to the firm.

   b. What is your role in each group?

   c. Are decisions made through informal group action? Or trends set? etc.

      If yes, describe the decisions, aids used, how decisions are arrived at, i.e. natural leader.

   d. Describe any automated aids the groups use to impact group decision making or would like to use or have used.

ENVIRONMENT

1. Place the description of your environment along this continuum.

STABLE		DYNAMIC
0	5	10

2. Where does the information come from that helps you make decisions?

INTERNAL TO FIRM		EXTERNAL TO FIRM
0	5	10

3. Are your problems of a more operational control or planning in nature?

OPERATIONAL CONTROL		PLANNING
0	5	10

4. What automated support do you get to help make decisions?

   List characteristics.

5. What external environmental factors or data affect your decision making with respect to the firm's business?

   RANK THEM

6. What internal environmental factors?

   RANK THEM

7. Describe any automated aids you use to deal with environmental factors.

TASK

1. Describe your general area of responsibility - your job.

2. A well-structured task consists of a precisely defined set of duties which must be accomplised in a given time period. Generally the structured task is repetitive with a relatively short cycle time.

   A highly unstructured task is the opposite, i.e., loosely defined, not repetitive, upredictable, non-cyclical and cannot be well anticipated.

   Please place an X on the following lines to indicate your perception of the structuredness of your task.

   a. STRUCTURED ____________________ NOT-STRUCTURED
   0 5 10

   b. INDIVIDUAL ORIENTED ____________________ GROUP ORIENTED
   0 5 10

   c. SHORT TIME TO MAKE DECISION LONG
   0 5 10

   d. COST IMPLICATIONS
   LOW ____________________ HI
   0 5 10

e. VALUE TO FIRM
VALUABLE BUT NOT CRITICAL ____________________ CRITIC
0 5 10

3. Describe the automated support you get and would like to get to support you in this task(s).

STRUCTURE

1. FORMAL

   a. How does your formal structure look to you?

      LINE -

      STAFF -

      FUNCTIONAL -

      MATRIX -

      NONE OF THESE - other

2. Is a formal organization chart available? Can I have a copy? Does this chart resemble how you perceive the firm? How do you perceive the firm?

3. INFORMAL

   a. How does the informal structure look to you?

      Centralized -

      Consultative -

      Transactional -

      Partially Delegated -

      Decentralized -

      Other - what? -

INDIVIDUAL (Leader Style)

1. a. What technical education or background do you have?

   b. Are you more interested in the technical or people aspects of your job? Or other?

   c. Do you work directly with the information system analyst? If no - at what level or through how many levels do you?

2. a. How would you best describe how you get your job done.

   . With a group consensus

   . Personnel evaluation and decision making

   b. Do you need to have more personal initiative to get things done or do you rely on managing others initiatives?

   c. Do you spend more time planning, communicating, reviewing accomplishments or reviewing daily operations (production control)?

3. To what degree do you view your approach as:

_______ a. Autocratic (dictatorial): leaders make decisions and allow subordinates no influence in decision-making process. Often indifferent to personal needs of subordinate or others.

_______ b. Participative (democratic): Consultative. Allow subordinates some influence on decision making.

INDIVIDUAL (Leader Style) (CONT'D)

______ c. Laissez Faire (free reign): Allow groups free autonomy. Rarely exercise direct decision making. Group makes their own on-the-job decisions.

4. To what degree are you
   a. ____________ concerned with effectiveness
   b. ____________ concerned with efficiency
   c. ____________ people centered
   d. ____________ work centered

5. To what degree do you
   a. ____________ set workers goals
   b. ____________ provide methodology to acheive goals
   c. ____________ measure goal attainment
   d. ____________ coach workers toward goal(s)

TECHNOLOGY

1. Technology refers to the use of modern technology within your firm to accomplish its primary objectives. Based on this definition place an X on each of the following horizontal lines to represent your perception of your firm's involvement with technology.

LOW   HIGH

a. TOOLS
____
0   10

b. METHODS
____
0   10

c. LEVEL OF TECHNOLOGY
____
0   SKILLS   10
FIRM OVERALL

d. MACHINES
____
0   10

DECISION SUPPORT SYSTEMS (DSSs)

1. DSSs are designed specifically for use and control of managers.
   Describe what DSSs
   a. you use
   b. have used and why you no longer use it (them)
   c. you think would be useful to you

2. How would you describe what the phrase "decision support system" brings to mind for you?

3. Describe any support you are provided by computerized systems, an information services dept. or similar ADP function.
   An OR function.

WRAP-UP

1. What seems to you to be the variables that could best be used to model your firm - your type of business - or your particular function in this firm?

2. What DSSs have you used, are aware of or might like to see implemented?

3. In your view why is your firm <u>not</u> using (or using more) DSSs?

Thank you very much for your time and consideration.

APPENDIX B

DECAIDS Tutorial [1]

The EMCYN structure was designed and implemented by a research group at Stanford University, Palo Alto, California. It contains the essential components needed to create and support an interactive consultation program. These essential components are the consultation program, predicate functions and their translations, the explanation subprogram, and the question-answering subprogram. This last feature is currently not functioning in EMYCIN and hence not in DECAIDS.

The subject domains to which EMYCIN has been applied range from human blood disease diagnosis to structural analysis (Scott, 1979). The domain of the prototype program developed in this research is decision support system capabilities and is named "DECAIDS." In order to implement this domain, a knowledge base was created and fitted into the EMYCIN format.

The objectives of the tutorial are to:

1. introduce the computer-naive user to the EMYCIN structure and the DECAIDS system,

[1]From the combined research of Roland, Buscemi and Masica.

2. provide users with the required background and documentation in order to further develop DECAIDS or develop a unique system of their own,

3. demonstrate the basic features of a knowledge base system through the use of a very simple example,

4. introduce the INTERLISP programming language and provide users with sufficient information concerning its syntax and functions for use with the DECAIDS system, and

5. produce an interactive system which will provide managers with recommended decision aid characteristics based on organizational characteristics unique to their personal situation.

The first and second objectives are related and will provide users with the basic concepts involved in producing a working system. It is assumed the user does not possess a background in computer science and every effort will be made to explain these concepts in an understandable manner.

This tutorial provides an introduction to INTERLISP. The documentation contained in the tutorial and Appendices C and I is intended to furnish users with sufficient knowledge of INTERLISP so that they can work with the DECAIDS system.

Finally, the use of the DECAIDS prototype demonstrates knowledge base features and provides the basis for the fifth objective. It is anticipated that DECAIDS will be greatly expanded and improved by future users.

Knowledge Base Systems

The building blocks of the knowledge base are contexts, parameters, goal-parameters, and production rules. The first step in the creation of a knowledge base is the creation of the tree structure which represents the subject domain. (Figure VI-2 provides the logical tree structure or knowledge base of the DECAIDS system.) The selection of the subject creates the root-context for the context tree. The root context will have one or more goal-parameters which represent the ultimate "recommendations" to be inferred from production rules. The various branches of the context tree are represented by parameters used to describe the subject domain of the tree. The ultimate objective is to write a set of production rules which relate parameters with appropriate goal-parameters. Goal-parameters can be defined as those parameters which are concluded from the production rules. This objective is accomplished by writing questions about the system parameters in natural language (i.e., English). The responses to these questions will constitute the information contained in the knowledge base.

The system parameters must be declared next. The following section and Appendix H contain definitions and examples of the various parameter properties. These properties must be provided by the system designer when the parameters are declared (entered on the computer system).

The knowledge base system production rules are written in the following format:

If: $\quad$ parameter$_1$ = value$_1$,

and parameter$_2$ = value$_2$,

and parameter$_m$ = value$_m$,

Then: $\quad$ Goal-parameter$_1$ = goal-value$_1$ (cf),

and goal-parameter$_n$ = goal-value$_n$ (cf).

Each value for the goal-parameters may have its own certainty factor (cf) assigned. A certainty factor is a relative weight based upon probabilistic reasoning by the expert who provides the knowledge base. In EMYCIN/DECAIDS, these certainty factors range from -1.0 to 1.0 in increments of 0.1.

The successful construction of a knowledge base depends greatly on the fact that conditional statements are related to all of the declared parameters. These conditional statements are actually a set of backward-chaining rules which eventually conclude the declared goal-parameter(s). For example, in the DECAIDS system one of the current goal-parameters is "DECAIDS." Therefore, production rules must eventually assign "DECAIDS" some value, i.e.,

If: $\quad$ Parameter X is Value Y,

Then: $\quad$ Conclude "DECAIDS" equals (recommendation).

The value of parameter X is provided to the program during the interactive session. The recommendations for this particular goal-parameter (DECAIDS) consist of the four parameters called TYPSYS, OUTPUT, INSTALL, and TRG. These parameters were explained in Chapter VI.

The successful implementation of this type of system depends upon providing a chain of reasoning that will "find" parameter values and lead to the "selection" of desired goal-parameter values. This can be accomplished by first writing in English the conditional statements related to parameters that will eventually conclude the goal-parameters. From this format specific rules can easily be transposed into the INTERLISP language. The EMYCIN monitor selects the order in which conditional statements are processed. The system designer can control the direction of the interactive session by ordering the parameters (of the context's MAINPROP property) in a manner which makes the session flow easily. This is accomplished because the system asks its questions (PROMPTS) in the same order that these MAINPROPS are listed.

<u>System Properties</u> The following properties are used in DECAIDS to implement system additions after the appropriate production rules have been written.

1. <u>Contexts</u>

The knowledge base is centered around the "object-attribute-value" triple. The object portion of this

triple is the context. A context is some entity made up of related parameters. Each system, i.e., DECAIDS, that is constructed must have at least one context (or root) which is the subject for that system.

In DECAIDS, the context is "ORGANIZATION." The relative simplicity of the current DECAIDS knowledge base lends itself to the use of this single context. In more complex domains, it may become necessary to organize system attributes into multiple contexts. For example, EMYCIN uses PERSON (the root context), CULTURES (the results of infectious cultures), and ORGANISMS (the type of organisms obtained from cultures and treatment which is to be prescribed) (Davis, 1977). Based upon system complexity system designers must decide a priori how parameters are to be organized into contexts. Relatively large systems can be organized under one context with proper organization. However, if multiple contexts are used, they must be arranged in a context tree which allows the production rules to refer to parameters of more than one related context. This is accomplished with the EMYCIN context properties known as ASSOCWITH and OFFSPRING. These properties are lists of ancestor and descendent context types, respectively.

Contexts are declared in a manner similar to that used to declare parameters. (This is true because contexts are also parameters.) These specific procedures are discussed in the following section.

The primary properties which must be declared for contexts are: MAINPROPS, TRANS, PROPTYPE, TYPE, RULETYPE, and GOALS. Other properties, included as Appendix H, are necessary for describing systems which are more complex than the prototype DECAIDS. These names are system names and are explained as follows.

MAINPROPS - These are the main parameters which describe a context. These parameters are declared as a list and are used to "trace" or define the context. The consultation session includes an interactive phase where these MAINPROPS are asked of the user. User responses will invoke the appropriate production rules with the ultimate result being various recommendations. The order in which these parameters are listed in the property of MAINPROPS assists in providing a more logical or "coherent" consultation for the user.

TRANS - The TRANS, or translation property, is the literal translation of the context (or parameter). This definition describes how the context will be translated in the program. In DECAIDS, the TRANS of the context ORGANIZATION is "the organization."

PROPTYPE - Property type is used by the system to identify which context a particular parameter belongs to. DECAIDS contains one PROPTYPE for ORGANIZATION, i.e. PROP-ORG.

TYPE - This property is the name used to identify contexts. For example, successive consultations involving the context organization will be titled "ORGANIZATION 1, ORGANIZATION 2, ORGANIZATION...".

RULETYPE - This is a list of the rules which must be searched in order to find a particular parameter. ORGANIZATION currently has only one ruletype, ORGRULES, which contains all rules to determine the goal-parameters. This name was chosen to stand for "organization rules."

GOALS - This is a list of goal-parameters which are applicable to the context. More than one goal is allowable. This permits more complex systems to be represented by single contexts. Current goal-parameters for ORGANIZATION are DECAIDS, UNKSTRUC, and FORSTRUC.

2. Parameters

Parameters are defined as attributes which describe a given context. In the knowledge base the parameters are the attribute portion of the "object-attribute-value" triple. These attributes may be thought of as questions to be asked (of the user or the system) that describe the context. For example, the system designer will ask the following type of questions, "Is the 'parameter' of the 'context' a 'value'?" The values correspond to appropriate answers to the designer's questions. These are pre-specified (if appropriate) by declaring them in the EXPECT property of the particular parameter and are explained later in this section.

The use of parameters in production rules has been discussed. Parameters are contained in the various lists with names of the form PROP-type. This form indicates a prompt which the user will answer. These lists are further collected into either PROPGROUPS or AUXPROPGROUPS. PROPGROUPS initially contain the reserved word PROP-VAL, which is the PROPTYPE for contexts, and eventually contain each parameter group declared in the context's PROPTYPE property. (Keep in mind that contexts are declared in the same manner as parameters.) AUXPROPGROUPS are lists of auxiliary parameters which serve varying purposes. The most useful of these purposes is defining a RULEGROUP. A RULEGROUP is explained in the following section.

The most frequently used parameter properties in the DECAIDS system are : TRANS, PROMPT, EXPECT, REPROMPT, and LABDATA.

TRANS - This is the literal translation of the parameter. TRANS is declared in the same manner as contexts.

PROMPT - This property is the natural language text question which is asked of the user concerning each parameter. Care should be taken when composing prompts so that the consultation dialogue makes sense to the user. (The context's MAINPROPS property can be used to assist in making the consultation flow smoothly and logically. Parameter PROMPTS are asked in the same order as the parameters are listed in the MAINPROPS.)

EXPECT - These are the accepted or "expected" responses to the PROMPTS. The specific values may be supplied by either the system designer or the user. In order to specify that anything is an appropriate answer, the word "ANY" should be entered as the EXPECT value of that parameter. If a parameter has a PROMPT, it must also have an EXPECT value.

REPROMPT - These are additional natural language text statements which are used to further explain the question asked by parameter PROMPTs. They are of great value to the designer and user because they can remove ambiguity concerning PROMPT meanings. They automatically list the accepted responses which the system will recognize. This property is invoked when the user responds with a question mark when asked a parameter PROMPT.

LABDATA - This property is a system key that indicates that the user will provide a value for that parameter. This is done by entering "T" as the value for LABDATA.

An example of these various properties is provided for the following DECAIDS parameter:

FORMAL:	(Parameter name)
TRANS:	(The organization's structure)
PROMPT:	(The formal structure of the organization can be defined as either line, staff, matrix, functional, or not available. If further explanation of

these terms is needed, type a question mark. "What is the organization's formal structure?"

EXPECT: (Line, Staff, Functional, Matrix, Not Available)

LABDATA: T

REPROMPT: (Line - emphasizes direct chains of authority and unity of command. Staff - includes an informational and advisory staff to assist and guide operational personnel. Functional - arranges personnel by functional activity such as logistics, communications, etc. Matrix - draws personnel from across departmental lines.)

3. Rulegroups

All rules must be assigned to groups called rulegroups prior to being declared (entered in the system). If no rulegroup is defined, the rules will not compile. Rulegroups are determined by the type(s) of context to which a rule may apply. Generally, a rule is applicable to the lowest context in the tree whose parameters appear in its PREMISE or ACTION. The group for the rule must be in the RULETYPES property of the applicable context type(s). In most cases, the RULETYPES property will be a list of a single group. All rulegroups are members of the parameter group called ALLNAMES. The use of ALLNAMES is covered in the GETPARMS section of this appendix. Before entering rules, it is necessary to define and initialize all rulegroups which are named "typeRULES." The procedure for accomplishing this is to type "SET(typeRULES NIL)" and then define the group by

the GETPARMS routine. (The word type in lower case letters refers to the specific type used. In DECAIDS, the rulegroup is called ORGRULES. This stands for organization rules.)

Rulegroups have the following properties:

CONTEXT - This is the list to which rules of this type apply.

SVAL - This property tells how to translate the reserved word "CNTXT" in rules of this type.

CTRANS - This is a phrase in English (a translation) describing what context types the rules apply to. This translation fills in the blank in the EMYCIN system phrase, "this rules applies to ______." This explanation precedes actual rules when rules are actually printed by the PRINTRULES routine. The use of this routine is explained in the next section.

Getting Started

1. Accessing DECAIDS

The DECAIDS system currently resides on a computer at the Information Sciences Institute of the University of Southern California. Access is accomplished through the ARPANET. The different uses and further background material on the ARPANET are not contained in this paper. The specific procedures used to access the DECAIDS system on the ARPANET are contained in Appendices C and I.

2. GETPARMS

The EMYCIN structure contains a routine, GETPARMS, which is used to declare all contexts, parameters, and rule groups. After logging onto the ARPANET and entering the EMYCIN executive file, EMYCIN.EXE, (as discussed in Appendix C) the procedures outlined in Appendix I are used to enter, edit, or delete parameters.

The most frequently used parameter properties in DECAIDS are: TRANS, EXPECT, PROMPT, LABDATA, and REPROMPT, as discussed previously. The most important of these properties is PROMPT as it "prompts" the natural language question which will be asked of the user concerning a particular parameter. The PROMPT should be written in such a manner as to present a logical dialogue to the user. The LABDATA property is a system key which indicates that the appropriate value of a parameter must be obtained from the user.

3. GETRULES

The GETRULES routine is used to declare system rules after the various parameters have been entered. These system rules are written to arrive at a final goal and thereby conclude the value of a parameter. Appendix I contains the specific procedures to be followed when using GETRULES.

Rules are entered in two parts, PREMISE and ACTION. Following the final parentheses in the ACTION clause, the rule is checked for syntactic validity and an error message is returned if an error is detected. If the subject of the rule cannot be deduced, the user is asked to confirm the rule group. The proper response is "Y" (yes) if the offered rulegroup is correct or the rule group is entered.

There is a useful feature that may be used in conjunction with either GETRULES or GETPARMS. If, during the course of entering rules or parameters, the user discovers the necessity of returning to the other routine, he may do so by typing "RULES" (in GETPARMS) or "PARAMETER" (in GETRULES). This facilitates writing a set of parameters and then calling GETRULES to declare the relevant rules.

The recommended format for entering rules is the INTERLISP syntax. A "terse" English form is available but requires much more typing. Additionally, in preparing the rules via the INTERLISP syntax, the concept of writing a set of rules to produce backward-chaining (which drives the direction of a consultation) becomes more apparent. Most of the premise clauses will be calls to the predicate functions SAME, NOTSAME, or KNOWN. These can be written as:

INTERLISP:	terse meaning:
(SAME CNTXT parm value)	parm = value
or	
(NOTSAME CNTXT parm value)	parm ≠ value

The following example is from DECAIDS:

```
(SAME CNTXT STRESS LOW)     STRESS = LOW
```

Similarly, the numeric predicates can be entered as:

```
INTERLISP:
GREATERP*   (VAL1 CNTXT parm)  number)

Terse meaning:
parm value  = number
```

No numeric predicate functions are currently used in DECAIDS.

ACTION statements will contain functions that conclude about one or more of the context-parameter-value triples. A certainty factor (cf) for the triple is specified in the rule's ACTION. This certainty factor will be modified by the certainty of the rule's PREMISE. The function "$AND" sets the reserved word TALLY to the certainty of the PREMISE, defined to be the minimum of the values returned by evaluating the PREMISE clauses (only SAME and THOUGHTNOT return numbers). The conclusion may be written as:

```
(CONCLUDE CNTXT parm value TALLY cf)
parm = value (cf)
```

The following example is from DECAIDS:

```
(CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
type system = real-time with a certainty of
0.8
```

The certainty factors are actually written in the range -1000 to 1000. This range represents the -1 to 1 mentioned earlier. The system writer should use the numbers in the preceding range in a call to CONCLUDE or other ACTION functions.

The function DO-ALL is used to conclude about the several parameters which comprise any multi-valued parameter, such as DECAIDS. Once a goal-parameter has been traced, the rule calling for PRINTCONCLUSIONS will be evaluated true and an output statement will be generated. (See rule 001 in Appendix E.)

4. Declaring the Treeroot and the RULEGROUP Type

Once it has been decided what the system objective is, the context tree is designed and filled in. It is necessary to make the following system declaration. From the EMYCIN.EXE, (not GETPARMS or GETRULES) the "SET" command is used to define the context tree root in the following format:

```
_SET(TREEROOT rootcontxt)
_SETQ(ROOTTYPE (GETP 'rootcontext'TYPE)).
```

An example of the procedure using a DECAIDS example follows:

```
_SET(TREEROOT ORGANIZATION)
_SETQ(ROOTTYPE (GETP 'ORGANIZATION'TYPE)).
```

The "_" is the EMYCIN.EXE prompt. Upper or lower case letters may be used to set the rootcontext name. This function should be performed along with "SETting" the RULEGROUP:

_SET(ruletype)

In DECAIDS:

_SET(ORGRULES).

The preceding examples contain capital letters because capitals were used throughout the DECAIDS system.

In order to save items such as the treeroot and rulegroup declarations, it is necessary to edit the CHANGESCOMS files. This file is a list delineating what should be stored on the CHANGES current program file. With the command "MF CHANGES," the editing, additions and deletions to GETPARMS and GETRULES are saved. However, the following procedure must be used to save the treeroot and rulegroup. (The "_" is the EMYCIN prompt and the "*" is the INTERLISP prompt.) The following is an example from DECAIDS:

_EV CHANGESSCOMS	(This command edits the variables that follow.)
*(-1 TREEROOT)	("1" means insert the following before the first element in the list.)

```
*SET(TREEROOT ORGANIZATION)

*SETQ(ROOTTYPE (GETP 'ORGANIZATION' TYPE))

*SET(ORGRULES)

*OK                          (This exits the editor and
                             the file must be saved
                             with MF CHANGES.)
```

5. <u>Saving Changes to Rules and Parameters and Deleting Changes</u>

Each update, addition, deletion, or edit to the system knowedge base is referred to as a CHANGE. Each CHANGE requires the complete recopying of the entire program. The command used to save these changes is "MF CHANGES." A new file is created each time the user enters the system. This file is comprised of all previous information that has been entered plus the new entries to the knowledge base. Accordingly, there is no need to keep multiple copies of the previous CHANGES after creating a file of new CHANGES. These "old" copies may be deleted by using the command, "DEL CHANGES..(number to be deleted)." If no number is specified, the lowest number version (or oldest) will be deleted. (During the login procedures, the entire file status is presented to the user. The CHANGES file will indicate exactly what number the user currently has in use.) Occasional naming conflicts have occurred with the operating systems, TENEX and TOPS-20, resulting in unwanted change deletions. It is therefore recommended that the user

maintain at least two or three changes as "insurance" against losing everything that has been entered.

6. Loading CHANGES

In order to run a consultation, it is necessary to concatenate the knowledge base with EMYCIN.EXE. This is done by the following command, "LOADEM CHANGES." The file which is currently in use has this command included in the executive login procedures and therefore does not have to be entered by the user.

7. Displaying Parameters

The following PRINTPARMS command should be used to display all or part of the parameters entered in the knowledge base:

"_PRINTPARMS(parm sort.by.group linelength file)

where parms may be a list of parameters, a list of parameter groups, a single parameter group, or NIL meaning all parameters. The term "sort.by.group" is T or NIL. T means that an alphabetical index is printed first, showing which group each parameter belongs in. NIL indicates that the parameters are listed in alphabetical order regardless of the group to which they belong. Linelength is the length of the line to be used, i.e., 72, 78, or 80 spaces. File is the name of the file in which to write the information. If T is used, the parameters will be written to the terminal. The

PRINTPARMS command may be used within the DRIBBLE command (which is explained in Section 9 of this appendix) to write the parameters into a separate file. An example of this command follows:

```
_PRINTPARMS(NIL T 72 T).
```

8. Displaying Rules

The procedure for displaying knowledge base rules is similar to the PRINTPARMS command. The command is:

```
_(PRINTRULES rules mode).
```

In this command, rules is a list of rules, or rule group, and mode indicates how the rules are to be printed. Mode includes these options:

B - both in English and INTERLISP

E - in English

L - in INTERLISP

J - for justification which permits inclusion of author's name.

9. Creating a File in the EMYCIN.EXE

In order to create a file of the knowledge base contents, the following sequence of commands is used:

_DRIBBLE(filename) — Where the filename is of the user's choice and DRIBBLE opens a typescript for the filename.

_PRINTPARMS (or PRINTRULES)

_DRIBBLE The last DRIBBLE command closes the file.

10. Running a Consultation

Appendix C contains the specific procedures that are required to run a consultation. This section contains supplementary information that is not found in that appendix.

The following special options are available when running a consultation "FT 1, 2, 3, 4, or carriage return "(no options)." FT stands for fault trace. The numbers that follow FT indicate the level of the "trace" desired with 1 being the lowest and 4 being the highest degree of fault, or rule, tracing. Fault trace 4 (FT4) will present each rule number as it is being sought, indicate that the FINDOUT routine is tracing the appropriate parameter, and complete with the FINISHED routing when a rule has been completely traced. Once the rule is evaluated as true, this is indicated by a message "RULE (#) SUCCEEDED."

At the other end of the scale, FT 1 will show those rules which have succeeded and then display their ACTION statements.

The user can request the following special features by entering one or more of the following options with spaces and ending with a carriage return:

I -	requests instructions to be printed.
OLD -	consider a previously-saved case (number(s) will be requested).
SAVE -	create and save files(s) for cases discussed in this consultation.
NOPR -	do not print out old questions and answers when running old cases.
SUMMARY -	summarize old session data, rather than printing out each question and answer.
UPDATE -	update old session data with new information.
TER -	enter terse mode.
TAB -	Tabular entry mode.
TS -	write out a typescript file of consultation.
N -	(a number) reconsider previously saved case n.
QA -	enter the question/answer module immediately skipping the consultation (currently turned off in EMYCIN). The terms "case" and "patient" remain from the original EMYCIN system referring to a medical consultation.

The following instructions are printed if the user responds "Y" when asked if instructions are desired:

Please answer the following questions, terminating each response with RETURN (CR). To correct typing errors, use the DELETE key to delete characters, (ctrl)W to delete a word and (ctrl)L to delete a whole line.

If you are not certain of your answer, you may modify the response by inserting a certainty factor (a number from 1 to 10) in parentheses after your response. Absolute certainty (10) is assumed for every unmodified answer. It is likely that some of the following questions cannot be answered with certainty. You may change an answer to a previous question in two ways. If the program is waiting for a response from you (that is, has typed "**"), enter CHANGE followed by the number(s) of the question(s) whose answers will be altered. You may also change a previous answer at any time (even when the program is not waiting for a response from you) by typing (ctrl)F (Fix),. which will cause the program to interrupt its compilation and ask what you want to change. If the response to (ctrl)F is not immediate, try typing the RETURN key in addition.) Try to avoid going back because the process requires reconsidering the case from the beginning and therefore may be slow. Note that you may also enter UNK (for unknown). If you do not know the answer to a question, ? if you wish to see a more precise definition of the question or some examples of recognized responses, ?? if you want to see all recognized responses, the word RULE if you would like to see the decision rule which has generated the questions being asked, the word WHY if you would like to see a more detailed explanation of the question, or the letters QA if you would like to interrupt the consultation in order to ask questions regarding the decision made so far in the consultation. If you are ever puzzled about what options are available to you during a consultation, enter the word HELP and a list of options will be listed for you.

Sample response[1] (user input follows "**")

> Does the patient have a risk factor for tuberculosis?
> **?
>
> One or more of the following are considered risk factors for TB: A) Positive PPD (5TU), B) History of close contact with a person having active TB, C) Household member with a past history of active TB, D) Chest x-ray showing apical scarring, E) Granulomas seen

[1]References to medical terms remained an integral part of EMYCIN upon its transfer from the computer at Stanford University to the equipment at the University of Southern California.

on biopsy of any organ tissue. Expected responses are: YES NO
Enter HELP for user options.
** YES

SUMMARY:
(Type ctrl-O to abort printout)

UNK - answer not known

? - rephrases the question and gives examples of recognized responses

?? - prints a list of all recognized responses

RULE - prints the current decision rule

QA - program enters question-answer mode

CHANGE - go back and re-request answer to question number # performance. Your comments will be forwarded to those in charge of the MYCIN program.

WHY - gives high level explanation of the current reasoning chain that provoked this question.

HOW # - explains HOW the system will achieve a goal referred to by a number # in a previous explanation.

EXPLAIN - provides a more detailed explanation of a previous answer given by a WHY command.

FORGET - resets the explanation of the reasoning chain back to the lowest level, as if you never used the WHY/EXPLAIN commands.

STOP - halts the program, saving the current case on a disk file, retrievable at a later date.

HELP - prints this list (Scott, 1979).

Once the user has answered the system queries concerning instructions and options, the consultation will begin. When a goal-parameter is found, the conclusion rule, currently called PRINTCONCLUSIONS, will be triggered and the consultation ended. An example consultation is contained in Appendix D. Fault trace 4 (FT 4) was selected for this sample consultation.

11. INTERLISP EDITOR

Chapter Nine of the INTERLISP Reference Manual fully describes the editor used with the DECAIDS system [Teitelman, 1974]. The editor is entered from the EMYCIN.EXE by typing "E" and may be reached from GETPARMS or GETRULES in order to change parameters or rules. The following is a short list of the most often used editor commands:

n	- (n is a positive integer) move to the nth element of the list where the element is a parenthetical expression.
p	- print the current expression, used with GETPARMS or GETRULES.
-n	- move to the nth element from the end.
(-n X)	- insert X after the current element.
B X	- insert X before the current expression.
:	- delete the current expression.
: X	- replace the current expression with X.
OK	- ends editing.

The "MF CHANGES" command is used to save all the editing which has been done.

12 Miscellaneous DECAIDS Notes

The following notes are included as information that applies to the DECAIDS program.

The INTERLISP compiler compiles upper and lower case letters differently. Either may be used to fill a knowledge base. For example, "DECAIDS" will compile differently than "decaids" and subsequent use in rules will result in an error message stating that there are not rules to conclude one or the other. Because of this problem, DECAIDS was entered on the machine in all capital letters. The system permits a consultation user to respond with "unknown" to a request for information which is not known to the user. This "UNK" means that the certainty factor for the rule should be set to less than .2, the system's arbitrary limit for acceptable knowledge about a parameter. Therefore, if the system writer desires to provide some other certainty factor about an unknown condition, he must offer a substitute response for "UNK" in the expect values. "NOTAVAILABLE" was the choice used in DECAIDS.

Rule 035 is the print statement for the goal-parameter UNKSTRUC. If UNKSTRUC was not known, then a recommendation was made about the informal organization structure to be recommended. If UNKSTRUC was known, no output was necessary. To "turn off" the output, even though UNKSTRUC had been traced, the HEADER in the PRINTCONCLUSIONS function (Appendix I) was left at NIL.

In rule 034, a parameter in the rule PREMISE is also used in the ACTION. In the parameter's USED-BY property (a system property not used by the designer) the note

SREFMARK 34 appears. This means that the parameter is in the PREMISE and ACTION of rule 034 and is a system flag to prevent various search and circularity problems

The parameter property REPROMPT is used to locate the text presented to the consultation user if and when he responds with a "?" for an expected parameter value. The system designer includes further explanation of expected values or the parameter definition in the REPROMPT.

The "WHY" response to a question rather than an allowed expected value produces an explanation of the current reasoning chain that provoked the current question . For the "WHY" question to work, the system writer must previously have used the LISP SET command to set the value of FINDBESTPARM. This value is used to an EMYCIN to provide text to explain the reasoning chain.

If intermediate values are desired to be known, not necessarily those of the goal-parameters, the system writer need only write a rule to "PRINTCONCLUSION" for that parameter.

Summary

This tutorial is included to show how a system such as DECAIDS can be created and/or modified. It has been designed so that it may be removed from this work if desired and used as a complete, independent section. The value of such an appendix can only really be appreciated by those who have reviewed some outstanding conceptual research only to discover no provisions are readily available to implement the concepts.

APPENDIX C

DECAIDS User Prodecures[1]

In order to present the procedures necessary to use the DECAIDS prototype decision support system, the following quick reference material is provided. All TOPS-20 and EMYCIN/DECAIDS commands must be followed by a carriage return to enter the user command or response. A sample consulation is presented in Appendix D.

1. Select the desired ARPANET compatible terminal to be used.

2. Connect to the local ARPANET TIP.

3. If using dial-up device, upon receiving the carrier tone, connect the telephone to the terminal's modem.

4. Depress the "RETURN" key once.

5. The following will be printed by the system:

    NPS TIP 420#: 2

6. The user next enters

    @l 116

This will connect the user to the University of Southern California's Information Sciences Institute System E computer referred to as ISIE.

[1]From the combined research of Roland, Buscemi and Masica.

7. The system will respond with:

TRYING ...

OPEN

ISI-SYSTEM-E. TOPS-20 MONITOR 3A(105)

@

The "@" symbol is the TOPS-20 operating system's prompt. After this symbol, a user may enter his commands or reponses.

8. The user next enters:

LOG DECAIDS escape

9. On the same line with the last entry, the user will be challenged with:

(PASSWORD)

10. The user must respond to (PASSWORD) with:

"PASSWORD" escape.

(The actual "password" may be obtained from the author.)

11. Again on the same line as above, the user will be challenged with:

(ACCOUNT)

12. The user's proper response to (ACCOUNT) is to enter a carriage return.

13. The current TOPS-20 operating system will respond with accounting data, date, and user file information. This information may be viewed or terminated with:

Control O

14. At the end of the login information the "@" prompt will be returned by the TOPS-20 operating system. At any time after login has been completed, the user may enter a:

Control C

in order to return to an "@" prompt and thereby facilitate a quick exit or log off with the command:

LOGO

15. To enter the EMYCIN/DECAIDS system, the user must type:

EMYCIN.EXE.2

16. The EMYCIN.EXE will respond with:

LOADING CHANGES ...

FILE CREATED (date) and (time)

CHANGESCOMS

(<DECAIDS> CHANGES..current number)

(<DECAIDS> EMYCIN.EXE.8.<DECAIDS>LISP.EXE.80516)

_

17. The "_" is the EMYCIN prompt symbol after which DECAIDS commands may be issued.

18. To begin the DECAIDS consulation program, the user enters the characters:

BEGIN]   (Note no carriage return)

The right square bracket must be entered. A short delay (10 to 30 seconds) may be experienced before the next system response occurs.

19. The user will next be challenged with:

SPECIAL OPTIONS (TYPE ? for HELP)

20. The user may respond with a carriage return if no special options, such as fault tracing (i.e., FT 1 or 2 or 3 or 4), are desired or with a "?" if an explanation of available options is desired.

21. The sytem will next challenge the user with:

INSTRUCTIONS (Y or N)

22. On the same line a "Y" response to 21 above will present a line of instructions on the use of the DECAIDS system and an "N" will continue with the DECAIDS consulation session.

23. DECAIDS will continue with the consulations by presenting the user with:

(current date) and (current time)

____________ORGANIZATION=1_________________

1) THIS PROGRAM IS DESIGNED TO PROVIDE MANAGERS AT ALL LEVELS WITH ADVICE RESOURCES.
IN ORDER TO PROVIDE THIS INFORMATION, THE USER WILL BE ASKED TO FURNISH DATA CONCERNING: HIS ORGANIZATION, ITS LEVEL OF TRAINING, THE ORGANIZATIONS'S LEADER, THE ENVIRONMENT AFFECTING THE DECISION, AND THE TASK FACING THE ORGANIZATION. WHAT IS THE TYPE OF PROBLEM WHICH THE ORGANIZATION FACES?

This is the beginning of the consultation session. This first question about the type of problem may be answered with any subject name, for example: electronic warfare. A full consultation session is presented in Appendix D.

24. The consultation will continue by asking ten additional questions for the user to answer at the end of which the user will be presented with the DECAIDS recommendations.

25. After the recommendations are offered, the system will ask:

Do you wish advice on another patient?

(Based originally on a medical background, the inference engine continues to ask for "patients.")

26. A user response of "Y" will start another consultation session with a title of ORGANIZATION-2 and an "N" response will return the user to the TOPS-20 operation system and its prompt of:

@

27. To leave the sytem entirely the user need only enter:

LOGO carriage return

28. The system will respond with:

KILLED JOB (#), USER DECAIDS, ACCOUNT NPS-OTHER-STUDENTS, TTY 167, AT (date, USED (time)

CLOSED

and the session is closed.

APPENDIX D

SAMPLE CONSULTATION[1]

```
 BEGIN)
Special options (type ? for help):
** FT 4
Instructions? (Y or N)
** NO

    ---------ORGANIZATION-2---------
    1) THIS PROGRAM IS DESIGNED TO PROVIDE MANAGERS AT ALL LEVELS WITH
       ADVICE CONCERNING THE USE OF THEIR COMPUTER RESOURCES. IN
       ORDER TO PROVIDE THIS INFORMATION, THE USER WILL BE ASKED TO
       FURNISH DATA CONCERNING: HIS ORGANIZATION, ITS LEVEL OF
       TRAINING, THE ORGANIZATION'S LEADER, THE ENVIRONMENT AFFECTING
       THE DECISION, AND THE TASK FACING THE ORGANIZATION.  WHAT IS
       THE TYPE OF PROBLEM WHICH THE ORGANIZATION FACES?
    ** THESIS
    2) THE FORMAL STRUCTURE OF THE ORGANIZATION CAN BE DEFINED AS
       EITHER LINE, STAFF, MATRIX, FUNCTIONAL, OR NOTAVAILABLE.  IF
       FURTHER EXPLANATION OF THESE TERMS IS NEEDED, TYPE A QUESTION
       MARK.  WHAT IS THE ORGANIZATION'S FORMAL STRUCTURE?
    ** NOTAVAILABLE
    3) THE INFORMAL STRUCTURE OF THE ORGANIZATION REFERS TO THE MANNER
       IN WHICH COMMUNICATION IS ACCOMPLISHED.  IS THE INFORMAL
       STRUCTURE BEST DESCRIBED AS CENTRALIZED, CONSULTATIVE,
       TRANSACTIONAL, PARTIALLY-DELEGATED, DECENTRALIZED, OR
       NOTAVAILABLE? IF FURTHER EXPLANATION IS NEEDED, TYPE A QUESTION
       MARK.
    ** NOTAVAILABLE
    4) IS THE ORGANIZATION'S STAFF'S LEVEL OF TECHNICAL TRAINING IN
       THE USE OF COMPUTERIZED TECHNICAL AIDS CONSIDERED SKILLED,
       UNSKILLED, OR UNKNOWN?
    ** SKILLED
    5) Is the task leader's technical training considered to be
       skilled, unskilled, or unknown?
    ** SKILLED
    6) IS THE TASK LEADER'S STYLE BEST DESCRIBED AS RELATION-
       ORIENTED,TASK-ORIENTED, OR UNKNOWN?
    ** RELATION-ORIENTED
    7) CONCERNING THE PROBLEM FACING THE ORGANIZATION, IS THE PROBLEM
       CLEARLY-DEFINED, AMBIGUOUS, OR UNKNOWN?
    ** CLEARLY-DEFINED
    8) IN REGARDS TO THE TECHNOLOGICAL TRAINING REQUIRED TO ACCOMPLISH
       THE TASK, IS THE LEVEL OF TECHNICAL TRAINING CONSIDERED TO BE
       SKILLED, UNSKILLED, OR UNKNOWN?
    ** SKILLED
    9) IS THE STRESS LEVEL CONSIDERED TO BE HIGH, LOW, OR UNKNOWN?
    ** HIGH
    10) DOES AN OPERATIONAL SYSTEM CURRENTLY EXIST?
    ** NO
    11) ARE THE TECHNOLOGICAL METHODS USED ANALYTICAL-AIDS, INVENTORY-
        AIDS, OR UNKNOWN?
    ** ANALYTICAL-AIDS
    --[1] Findout: DECAIDS of ORGANIZATION-2
Trying RULE002/ORGANIZATION-2;
    --[2] Findout: TYPSYS of ORGANIZATION-2
RULE036 failed (in preview) due to clause 1
RULE032 failed (in preview) due to clause 1
RULE031 failed (in preview) due to clause 1
```


[1]From the combined research of Roland, Buscemi and Masica.

```
RULE030 failed {in preview} due to clause 1
RULE029 failed {in preview} due to clause 1
Trying RULE028/ORGANIZATION-2; RULE028 succeeded.
Conclude: TYPSYS of ORGANIZATION-2 is UNAVAILABLE (.5)
Conclude: OUTPUT of ORGANIZATION-2 is UNAVAILABLE (.5)
Conclude: INSTALL of ORGANIZATION-2 is UNAVAILABLE (.5)
Conclude: TRG of ORGANIZATION-2 is DO-NOT-HIRE-SPECIALISTS (.8)
RULE027 failed {in preview} due to clause 1
Trying RULE026/ORGANIZATION-2; RULE026 succeeded.
Conclude: TYPSYS of ORGANIZATION-2 is REAL-TIME (.8)
Conclude: OUTPUT of ORGANIZATION-2 is INDIVIDUAL-TERMINALS (.8)
Conclude: INSTALL of ORGANIZATION-2 is PYRAMIDAL (.5)
Conclude: TRG of ORGANIZATION-2 is UNAVAILABLE (.8)
Trying RULE025/ORGANIZATION-2;
   --[no rules to conclude TRAINING of ORGANIZATION-2]
   12) IS THE TASK LEADER'S LEVEL OF TECHNICAL TRAINING CONSIDERED TO
       BE HIGH, LOW, OR UNKNOWN?
   ** HIGH
RULE025 failed due to clause 1
Trying RULE024/ORGANIZATION-2; RULE024 succeeded.
Conclude: TYPSYS of ORGANIZATION-2 is REAL-TIME (.96)
Conclude: OUTPUT of ORGANIZATION-2 is INDIVIDUAL-TERMINALS (.96)
Conclude: INSTALL of ORGANIZATION-2 is PYRAMIDAL (.9)
Conclude: TRG of ORGANIZATION-2 is TRAIN-EXISTING-STAFF (.8)
RULE023 failed {in preview} due to clause 1
RULE022 failed {in preview} due to clause 1
RULE021 failed {in preview} due to clause 1
Trying RULE020/ORGANIZATION-2; RULE020 succeeded.
Conclude: TYPSYS of ORGANIZATION-2 is NON-REAL-TIME (.8)
Conclude: OUTPUT of ORGANIZATION-2 is LARGE-SCREEN-DISPLAYS (.8)
Conclude: INSTALL of ORGANIZATION-2 is DIVISIONAL (.8)
Conclude: TRG of ORGANIZATION-2 is TRAIN-EXISTING-STAFF (.96)
RULE019 failed {in preview} due to clause 1
RULE018 failed {in preview} due to clause 1
RULE017 failed {in preview} due to clause 1
RULE016 failed {in preview} due to clause 1
RULE015 failed {in preview} due to clause 1
RULE014 failed {in preview} due to clause 1
Trying RULE013/ORGANIZATION-2; RULE013 succeeded.
Conclude: TYPSYS of ORGANIZATION-2 is REAL-TIME (.992)
Conclude: OUTPUT of ORGANIZATION-2 is INDIVIDUAL-TERMINALS (.992)
Conclude: INSTALL of ORGANIZATION-2 is PYRAMIDAL (.98)
Conclude: TRG of ORGANIZATION-2 is DO-NOT-HIRE-SPECIALISTS (.96)
RULE009 failed {in preview} due to clause 1
Trying RULE008/ORGANIZATION-2; RULE008 succeeded.
Conclude: TYPSYS of ORGANIZATION-2 is REAL-TIME (.998)
Conclude: OUTPUT of ORGANIZATION-2 is INDIVIDUAL-TERMINALS (.998)
Conclude: INSTALL of ORGANIZATION-2 is PYRAMIDAL (.996)
Conclude: TRG of ORGANIZATION-2 is DO-NOT-HIRE-SPECIALISTS (.992)
RULE007 failed {in preview} due to clause 1
Trying RULE006/ORGANIZATION-2; RULE006 succeeded.
Conclude: TYPSYS of ORGANIZATION-2 is REAL-TIME (.999)
Conclude: OUTPUT of ORGANIZATION-2 is INDIVIDUAL-TERMINALS (.999)
Conclude: INSTALL of ORGANIZATION-2 is PYRAMIDAL (.999)
Conclude: TRG of ORGANIZATION-2 is DO-NOT-HIRE-SPECIALISTS (.998)
Trying RULE005/ORGANIZATION-2; RULE005 succeeded.
Conclude: TYPSYS of ORGANIZATION-2 is REAL-TIME (.999)
Conclude: OUTPUT of ORGANIZATION-2 is INDIVIDUAL-TERMINALS (.999)
Conclude: INSTALL of ORGANIZATION-2 is UNAVAILABLE (.75)
Conclude: TRG of ORGANIZATION-2 is HIRE-SPECIALISTS (.6)
Trying RULE004/ORGANIZATION-2; RULE004 succeeded.
Conclude: TYPSYS of ORGANIZATION-2 is REAL-TIME (.999)
```

```
Conclude: OUTPUT of ORGANIZATION-2 is INDIVIDUAL-TERMINALS (.999)
Conclude: INSTALL of ORGANIZATION-2 is PYRAMIDAL (.999)
Conclude: TRG of ORGANIZATION-2 is DO-NOT-HIRE-SPECIALISTS (.999)
RULE003 failed {in preview} due to clause 1
   --[2] Finished: TYPSYS of ORGANIZATION-2
   --[2] Findout: OUTPUT of ORGANIZATION-2
   --[2] Finished: OUTPUT of ORGANIZATION-2
   --[2] Findout: INSTALL of ORGANIZATION-2
   --[2] Finished: INSTALL of ORGANIZATION-2
   --[2] Findout: TRG of ORGANIZATION-2
   --[2] Finished: TRG of ORGANIZATION-2
RULE002 succeeded.
Conclude: DECAIDS of ORGANIZATION-2 is TEXT NIL
USE THE FOLLOWING TYPE SYSTEM REAL-TIME
THE OUTPUT SHOULD BE DISPLAYED ON INDIVIDUAL-TERMINALS
THE MANNER OF INSTALLATION SHOULD BE PYRAMIDAL
AND THE RECOMMENDATION FOR TRAINING AND ASSISTANCE IS
DO-NOT-HIRE-SPECIALISTS . (1.0)
   --[1] Finished: DECAIDS of ORGANIZATION-2
antecedent RULE001 succeeded.
Conclusions: THE DECISION are as follows:
        USE THE FOLLOWING TYPE SYSTEM REAL-TIME THE OUTPUT SHOULD BE
            DISPLAYED ON INDIVIDUAL-TERMINALS THE MANNER OF
            INSTALLATION SHOULD BE PYRAMIDAL AND THE RECOMMENDATION
            FOR TRAINING AND ASSISTANCE IS DO-NOT-HIRE-SPECIALISTS .

   --[1] Findout: UNKSTRUC of ORGANIZATION-2
Trying RULE033/ORGANIZATION-2; RULE033 succeeded.
Conclude: UNKSTRUC of ORGANIZATION-2 is CENTRALIZED (.8)
Trying RULE034/ORGANIZATION-2; RULE034 succeeded.
antecedent RULE035 succeeded.
        THE
            RECOMMENDED INFORMAL STRUCTURE TO USE IS CENTRALIZED.

Conclude: UNKSTRUC of ORGANIZATION-2 is TEXT NIL
THE
RECOMMENDED INFORMAL STRUCTURE TO USE IS CENTRALIZED (1.0)
   --[1] Finished: UNKSTRUC of ORGANIZATION-2
   --[1] Findout: FORSTRUC of ORGANIZATION-2
Trying RULE039/ORGANIZATION-2; RULE039 succeeded.
Conclude: FORSTRUC of ORGANIZATION-2 is LINE (.8)
Trying RULE040/ORGANIZATION-2; RULE040 succeeded.
antecedent RULE041 succeeded.
        THE RECOMMENDED FORMAL STRUCTURE TO USE IS LINE.

Conclude: FORSTRUC of ORGANIZATION-2 is TEXT NIL
THE RECOMMENDED FORMAL STRUCTURE TO USE IS LINE (1.0)
   --[1] Finished: FORSTRUC of ORGANIZATION-2
```

APPENDIX E

DECAIDS PRODUCTION RULES[1]

```
RULE001
-------
[This rule is definitional, applies to ORGANIZATION, and is tried
     when information is received about THE DECISION]

   If:  An attempt has been made to deduce THE DECISION
   Then:  Display THE DECISION


   PREMISE:  ($AND (ONCEKNOWN CNTXT DECAIDS T))
   ACTION:  (PRINTCONCLUSIONS CNTXT DECAIDS T)

[ORGRULES/antecedent]


RULE002
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE DECISION]

   If:   1) THE TYPE OF SYSTEM RECOMMENDED TO BE USED is known,
         2) THETYPE OF OUTPUT DEVICE TO BE USED is known,
         3) THE RECOMMENDED INSTALLATION TO BE USED is known, and
         4) THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is
            known
   Then:  It is definite (1.0) that the following is one of THE
             DECISION: USE THE FOLLOWING TYPE SYSTEM <typsys> THE
             OUTPUT SHOULD BE DISPLAYED ON <output> THE MANNER OF
             INSTALLATION SHOULD BE <install> AND THE RECOMMENDATION
             FOR TRAINING AND ASSISTANCE IS <trg> .


   PREMISE:  ($AND (KNOWN CNTXT TYPSYS)
                   (KNOWN CNTXT OUTPUT)
                   (KNOWN CNTXT INSTALL)
                   (KNOWN CNTXT TRG))
   ACTION:  (CONCLUDETEXT CNTXT DECAIDS (TEXT NIL
                                  'USE THE FOLLOWING TYPE SYSTEM'
                                          (VAL1 CNTXT TYPSYS)

                              'THE OUTPUT SHOULD BE DISPLAYED ON'
                                          (VAL1 CNTXT OUTPUT)

                          'THE MANNER OF INSTALLATION SHOULD BE'
                                          (VAL1 CNTXT INSTALL)

              'AND THE RECOMMENDATION FOR TRAINING AND ASSISTANCE IS'
                                          (VAL1 CNTXT TRG)
                                          '.')
                        TALLY 1000)
```


[1]From the combined research of Roland, Buscemi and Masica.

```
RULE003
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
    about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
    OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
    USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE ORGANIZATION'S STRUCTURE is centralized
  Then:   1) There is strongly suggestive evidence (.8) that THE TYPE
             OF SYSTEM RECOMMENDED TO BE USED is real-time,
          2) There is strongly suggestive evidence (.8) that THETYPE
             OF OUTPUT DEVICE TO BE USED is individual-terminals,
          3) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
          4) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is do-
             not-hire-specialists


  PREMISE:   ($AND (SAME CNTXT INFORMAL CENTRALIZED))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              800)
                    (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                    (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                              800))

[ORGRULES]


RULE004
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
    about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
    OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
    USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE LEADER'S LEVEL OF TRAINING is skilled
  Then:   1) There is strongly suggestive evidence (.8) that THE TYPE
             OF SYSTEM RECOMMENDED TO BE USED is real-time,
          2) Hire-specialists,
          3) There is strongly suggestive evidence (.8) that THETYPE
             OF OUTPUT DEVICE TO BE USED is individual-terminals,
          4) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
          5) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is do-
             not-hire-specialists


  PREMISE:   ($AND (SAME CNTXT LEADER-TRAINING SKILLED))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                    HIRE-SPECIALISTS
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              800)
                    (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                    (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                              800))

[ORGRULES]
```

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RULE005
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:  THE LEADER'S LEVEL OF TRAINING is known
  Then:  1) There is suggestive evidence (.5) that THE TYPE OF SYSTEM
            RECOMMENDED TO BE USED is real-time,
         2) There is suggestive evidence (.5) that THETYPE OF OUTPUT
            DEVICE TO BE USED is individual-terminals,
         3) There is suggestive evidence (.5) that THE RECOMMENDED
            INSTALLATION TO BE USED is unavailable, and
         4) There is suggestive evidence (.6) that THE RECOMMENDED
            TRAINING OR ASSISTANCE TO BE ACQUIRED is hire-specialists


  PREMISE:  ($AND (KNOWN CNTXT LEADER-TRAINING UNSKILLED))
  ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 500)
                   (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                             500)
                   (CONCLUDE CNTXT INSTALL UNAVAILABLE TALLY 500)
                   (CONCLUDE CNTXT TRG HIRE-SPECIALISTS TALLY 600))

[ORGRULES]


RULE006
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:  THE STAFF'S LEVEL OF TECHNICAL TRAINING is known
  Then:  1) There is suggestive evidence (.5) that THE TYPE OF SYSTEM
            RECOMMENDED TO BE USED is real-time,
         2) There is suggestive evidence (.5) that THETYPE OF OUTPUT
            DEVICE TO BE USED is individual-terminals,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
         4) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is do-
            not-hire-specialists


  PREMISE:  ($AND (KNOWN CNTXT STFFTRG SKILLED))
  ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 500)
                   (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                             500)
                   (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                   (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                             800))

[ORGRULES]
```

RULE007

```
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

   If:   THE STAFF'S LEVEL OF TECHNICAL TRAINING is unskilled
   Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
             OF SYSTEM RECOMMENDED TO BE USED is real-time,
          2) There is strongly suggestive evidence (.8) that THETYPE
             OF OUTPUT DEVICE TO BE USED is individual-terminals,
          3) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED INSTALLATION TO BE USED is divisional, and
          4) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is hire-
             specialists


   PREMISE:  ($AND (SAME CNTXT STFFTRG UNSKILLED))
   ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              800)
                    (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 800)
                    (CONCLUDE CNTXT TRG HIRE-SPECIALISTS TALLY 800))

[ORGRULES]
```

RULE008

```
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

   If:   THE LEVEL OF THE TASK'S STRESS is high
   Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
             OF SYSTEM RECOMMENDED TO BE USED is real-time,
          2) There is strongly suggestive evidence (.8) that THETYPE
             OF OUTPUT DEVICE TO BE USED is individual-terminals,
          3) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
          4) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is do-
             not-hire-specialists


   PREMISE:  ($AND (SAME CNTXT STRESS HIGH))
   ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              800)
                    (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                    (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                              800))

[ORGRULES]
```

RULE009

[This rule applies to ORGANIZATION, and is tried in order to find out about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

```
If:   THE LEVEL OF THE TASK'S STRESS is low
Then:  1) There is suggestive evidence (.5) that THE TYPE OF SYSTEM
          RECOMMENDED TO BE USED is real-time,
       2) There is suggestive evidence (.5) that THETYPE OF OUTPUT
          DEVICE TO BE USED is individual-terminals,
       3) There is suggestive evidence (.5) that THE RECOMMENDED
          INSTALLATION TO BE USED is divisional, and
       4) There is suggestive evidence (.5) that THE RECOMMENDED
          TRAINING OR ASSISTANCE TO BE ACQUIRED is do-not-hire-
          specialists


PREMISE:  ($AND (SAME CNTXT STRESS LOW))
ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 500)
                 (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                          500)
                 (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 500)
                 (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                          500))
```

[ORGRULES]

RULE013

[This rule applies to ORGANIZATION, and is tried in order to find out about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

```
If:   THE TASK DEFINITION is clearly-defined
Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
          OF SYSTEM RECOMMENDED TO BE USED is real-time,
       2) There is strongly suggestive evidence (.8) that THETYPE
          OF OUTPUT DEVICE TO BE USED is individual-terminals,
       3) There is strongly suggestive evidence (.8) that THE
          RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
       4) There is strongly suggestive evidence (.8) that THE
          RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is do-
          not-hire-specialists


PREMISE:  ($AND (SAME CNTXT PROBDEF CLEARLY-DEFINED))
ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                 (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                          800)
                 (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                 (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                          800))
```

[ORGRULES]

RULE014

[This rule applies to ORGANIZATION, and is tried in order to find out about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

```
  If:   THE TASK DEFINITION is ambiguous
  Then:   1) There is suggestive evidence (.5) that THE TYPE OF SYSTEM
             RECOMMENDED TO BE USED is real-time,
          2) There is suggestive evidence (.5) that THETYPE OF OUTPUT
             DEVICE TO BE USED is individual-terminals,
          3) There is suggestive evidence (.5) that THE RECOMMENDED
             INSTALLATION TO BE USED is divisional, and
          4) There is suggestive evidence (.5) that THE RECOMMENDED
             TRAINING OR ASSISTANCE TO BE ACQUIRED is do-not-hire-
             specialists


  PREMISE:   ($AND (SAME CNTXT PRODDEF AMBIGUOUS))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 500)
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              500)
                    (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 500)
                    (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                              500))
```

[ORGRULES]

RULE015

[This rule applies to ORGANIZATION, and is tried in order to find out about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

```
  If:   THE ORGANIZATION'S STRUCTURE is centralized
  Then:   1) There is strongly suggestive evidence (.8) that THE TYPE
             OF SYSTEM RECOMMENDED TO BE USED is real-time,
          2) There is strongly suggestive evidence (.8) that THETYPE
             OF OUTPUT DEVICE TO BE USED is individual-terminals,
          3) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
          4) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is do-
             not-hire-specialists


  PREMISE:   ($AND (SAME CNTXT INFORMAL CENTRALIZED))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              800)
                    (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                    (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                              800))
```

[ORGRULES]

```
RULE018
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
    about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
    OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
    USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE ORGANIZATION'S STRUCTURE is consultative

  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is individual-terminals,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is divisional, and
         4) There is suggestive evidence (.5) that THE RECOMMENDED
            TRAINING OR ASSISTANCE TO BE ACQUIRED is do-not-hire-
            specialists

  PREMISE:  ($AND (SAME CNTXT INFORMAL CONSULTATIVE))
  ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                   (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                             800)
                   (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 800)
                   (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                             500))

[ORGRULES]


RULE019
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
    about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
    OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
    USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE ORGANIZATION'S STRUCTURE is partially-delegated
  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is individual-terminals,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is divisional, and
         4) There is suggestive evidence (.5) that THE RECOMMENDED
            TRAINING OR ASSISTANCE TO BE ACQUIRED is hire-specialists

  PREMISE:  ($AND (SAME CNTXT INFORMAL PARTIALLY-DELEGATED))
  ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                   (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                             800)
                   (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 800)
                   (CONCLUDE CNTXT TRG HIRE-SPECIALISTS TALLY 500))

[ORGRULES]
```

```
RULE016
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE ORGANIZATION'S STRUCTURE is line
  Then:  1) There is suggestive evidence (.5) that THE TYPE OF SYSTEM
            RECOMMENDED TO BE USED is real-time,
         2) There is suggestive evidence (.5) that THETYPE OF OUTPUT
            DEVICE TO BE USED is individual-terminals,
         3) There is suggestive evidence (.5) that THE RECOMMENDED
            INSTALLATION TO BE USED is pyramidal, and
         4) There is suggestive evidence (.5) that THE RECOMMENDED
            TRAINING OR ASSISTANCE TO BE ACQUIRED is hire-specialists


  PREMISE:  ($AND (SAME CNTXT FORMAL LINE))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 500)
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              500)
                    (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 500)
                    (CONCLUDE CNTXT TRG HIRE-SPECIALISTS TALLY 500))

[ORGRULES]


RULE017
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE ORGANIZATION'S STRUCTURE is THE FORMAL COMPOSITION OF THE
           ORGANIZATION'S STRUCTURE
  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is individual-terminals,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
         4) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is do-
            not-hire-specialists


  PREMISE:  ($AND (SAME CNTXT FORMAL STAFF))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              800)
                    (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                    (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                              800))

[ORGRULES]
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```
RULE020
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
    about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
    OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
    USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE LEADER'S STYLE OF OPERATION is relation-oriented
  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is non-real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is large-screen-displays,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is divisional, and
         4) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is
            train-existing-staff

  PREMISE:  ($AND (SAME CNTXT STYLE RELATION-ORIENTED))
  ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS NON-REAL-TIME TALLY 800)
                   (CONCLUDE CNTXT OUTPUT LARGE-SCREEN-DISPLAYS TALLY
                             800)
                   (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 800)
                   (CONCLUDE CNTXT TRG TRAIN-EXISTING-STAFF TALLY 800))

[ORGRULES]

RULE021
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
    about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
    OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
    USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE ORGANIZATION'S STRUCTURE is transactional
  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is non-real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is individual-terminals,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is divisional, and
         4) There is suggestive evidence (.5) that THE RECOMMENDED
            TRAINING OR ASSISTANCE TO BE ACQUIRED is hire-specialists

  PREMISE:  ($AND (SAME CNTXT INFORMAL TRANSACTIONAL))
  ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS NON-REAL-TIME TALLY 800)
                   (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                             800)
                   (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 800)
                   (CONCLUDE CNTXT TRG HIRE-SPECIALISTS TALLY 500))

[ORGRULES]
```

RULE022

[This rule applies to ORGANIZATION, and is tried in order to find out about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

```
If:   THE ORGANIZATION'S STRUCTURE is decentralized
Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
          OF SYSTEM RECOMMENDED TO BE USED is real-time,
       2) There is strongly suggestive evidence (.8) that THETYPE
          OF OUTPUT DEVICE TO BE USED is individual-terminals,
       3) There is strongly suggestive evidence (.8) that THE
          RECOMMENDED INSTALLATION TO BE USED is divisional, and
       4) There is strongly suggestive evidence (.8) that THE
          RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is hire-
          specialists


PREMISE:  ($AND (SAME CNTXT INFORMAL DECENTRALIZED))
ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                 (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                           800)
                 (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 800)
                 (CONCLUDE CNTXT TRG HIRE-SPECIALISTS TALLY 800))
```

[ORGRULES]

RULE023

[This rule applies to ORGANIZATION, and is tried in order to find out about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

```
If:   THE LEADER'S STYLE OF OPERATION is task-oriented
Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
          OF SYSTEM RECOMMENDED TO BE USED is real-time,
       2) There is strongly suggestive evidence (.8) that THETYPE
          OF OUTPUT DEVICE TO BE USED is individual-terminals,
       3) There is strongly suggestive evidence (.8) that THE
          RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
       4) There is suggestive evidence (.5) that THE RECOMMENDED
          TRAINING OR ASSISTANCE TO BE ACQUIRED is unavailable


PREMISE:  ($AND (SAME CNTXT STYLE TASK-ORIENTED))
ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                 (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                           800)
                 (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                 (CONCLUDE CNTXT TRG UNAVAILABLE TALLY 500))
```

[ORGRULES]

```
RULE024
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
    about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
    OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
    USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:  THE INDIVIDUAL'S TECHNICAL TRAINING IN DECISION ANALYSIS is
         high
  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is individual-terminals,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
         4) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is
            train-existing-staff


  PREMISE:  ($AND (SAME CNTXT TRAINING HIGH))
  ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                   (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                             800)
                   (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                   (CONCLUDE CNTXT TRG TRAIN-EXISTING-STAFF TALLY 800))

[ORGRULES]


RULE025
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
    about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
    OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
    USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:  THE INDIVIDUAL'S TECHNICAL TRAINING IN DECISION ANALYSIS is
         low
  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is non-real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is large-screen-displays,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is divisional, and
         4) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is hire-
            specialists


  PREMISE:  ($AND (SAME CNTXT TRAINING LOW))
  ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS NON-REAL-TIME TALLY 800)
                   (CONCLUDE CNTXT OUTPUT LARGE-SCREEN-DISPLAYS TALLY
                             800)
                   (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 800)
                   (CONCLUDE CNTXT TRG HIRE-SPECIALISTS TALLY 800))

[ORGRULES]
```

```
RULE026
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE TECHNOLOGICAL METHODS AVAILABLE is analytical-aids


  Then:   1) There is strongly suggestive evidence (.8) that THE TYPE
             OF SYSTEM RECOMMENDED TO BE USED is real-time,
          2) There is strongly suggestive evidence (.8) that THETYPE
             OF OUTPUT DEVICE TO BE USED is individual-terminals,
          3) There is suggestive evidence (.5) that THE RECOMMENDED
             INSTALLATION TO BE USED is pyramidal, and
          4) There is strongly suggestive evidence (.8) that THE
             RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is
             unavailable


  PREMISE:   ($AND (SAME CNTXT METHODS ANALYTICAL-AIDS))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              800)
                    (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 500)
                    (CONCLUDE CNTXT TRG UNAVAILABLE TALLY 800))

[ORGRULES]


RULE027
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE TECHNOLOGICAL METHODS AVAILABLE is inventory-aids
  Then:   1) There is suggestive evidence (.5) that THE TYPE OF SYSTEM
             RECOMMENDED TO BE USED is real-time,
          2) There is suggestive evidence (.5) that THETYPE OF OUTPUT
             DEVICE TO BE USED is individual-terminals,
          3) There is suggestive evidence (.5) that THE RECOMMENDED
             INSTALLATION TO BE USED is pyramidal, and
          4) There is suggestive evidence (.5) that THE RECOMMENDED
             TRAINING OR ASSISTANCE TO BE ACQUIRED is unavailable


  PREMISE:   ($AND (SAME CNTXT METHODS INVENTORY-AIDS))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 500)
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              500)
                    (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 500)
                    (CONCLUDE CNTXT TRG UNAVAILABLE TALLY 500))

[ORGRULES]
```

RULE028

[This rule applies to ORGANIZATION, and is tried in order to find out about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

```
If:   The technological knowledge-level is skilled
Then:  1) There is suggestive evidence (.5) that THE TYPE OF SYSTEM
          RECOMMENDED TO BE USED is unavailable,
       2) There is suggestive evidence (.5) that THETYPE OF OUTPUT
          DEVICE TO BE USED is unavailable,
       3) There is suggestive evidence (.5) that THE RECOMMENDED
          INSTALLATION TO BE USED is unavailable, and
       4) There is strongly suggestive evidence (.8) that THE
          RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is do-
          not-hire-specialists

PREMISE:  ($AND (SAME CNTXT KNOWLEDGE-LEVEL SKILLED))
ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS UNAVAILABLE TALLY 500)
                 (CONCLUDE CNTXT OUTPUT UNAVAILABLE TALLY 500)
                 (CONCLUDE CNTXT INSTALL UNAVAILABLE TALLY 500)
                 (CONCLUDE CNTXT TRG DO-NOT-HIRE-SPECIALISTS TALLY
                          800))
```

[ORGRULES]

RULE029

[This rule applies to ORGANIZATION, and is tried in order to find out about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

```
If:   The technological knowledge-level is unskilled
Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
          OF SYSTEM RECOMMENDED TO BE USED is unavailable,
       2) There is strongly suggestive evidence (.8) that THETYPE
          OF OUTPUT DEVICE TO BE USED is unavailable,
       3) There is strongly suggestive evidence (.8) that THE
          RECOMMENDED INSTALLATION TO BE USED is unavailable, and
       4) There is strongly suggestive evidence (.8) that THE
          RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is hire-
          specialists

PREMISE:  ($AND (SAME CNTXT KNOWLEDGE-LEVEL UNSKILLED))
ACTION:  (DO-ALL (CONCLUDE CNTXT TYPSYS UNAVAILABLE TALLY 800)
                 (CONCLUDE CNTXT OUTPUT UNAVAILABLE TALLY 800)
                 (CONCLUDE CNTXT INSTALL UNAVAILABLE TALLY 800)
                 (CONCLUDE CNTXT TRG HIRE-SPECIALISTS TALLY 800))
```

[ORGRULES]

```
RULE030
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE ORGANIZATION'S STRUCTURE is line
  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is unavailable,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
         4) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is
            unavailable

  PREMISE:  ($AND (SAME CNTXT FORMAL LINE))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                    (CONCLUDE CNTXT OUTPUT UNAVAILABLE TALLY 800)
                    (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                    (CONCLUDE CNTXT TRG UNAVAILABLE TALLY 800))

[ORGRULES]

RULE031
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:   THE ORGANIZATION'S STRUCTURE is functional
  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is non-real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is unavailable,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is divisional, and
         4) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is
            unavailable

  PREMISE:  ($AND (SAME CNTXT FORMAL FUNCTIONAL))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS NON-REAL-TIME TALLY 800)
                    (CONCLUDE CNTXT OUTPUT UNAVAILABLE TALLY 800)
                    (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 800)
                    (CONCLUDE CNTXT TRG UNAVAILABLE TALLY 800))

[ORGRULES]
```

RULE032

[This rule applies to ORGANIZATION, and is tried in order to find out about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

```
  If:   THE ORGANIZATION'S STRUCTURE is matrix
  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is non-real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is unavailable,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is divisional, and
         4) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is
            unavailable


  PREMISE:  ($AND (SAME CNTXT FORMAL MATRIX))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS NON-REAL-TIME TALLY 800)
                    (CONCLUDE CNTXT OUTPUT UNAVAILABLE TALLY 800)
                    (CONCLUDE CNTXT INSTALL DIVISIONAL TALLY 800)
                    (CONCLUDE CNTXT TRG UNAVAILABLE TALLY 800))
```

[ORGRULES]

RULE033

[This rule applies to ORGANIZATION, and is tried in order to find out about the recommended informal structure]

```
  If:   THE ORGANIZATION'S STRUCTURE is notavailable
  Then:  There is strongly suggestive evidence (.8) that the
            recommended informal structure is centralized


  PREMISE:  ($AND (SAME CNTXT INFORMAL NOTAVAILABLE))
  ACTION:   (CONCLUDE CNTXT UNKSTRUC CENTRALIZED TALLY 800)
```

[ORGRULES]

RULE034

[This rule applies to ORGANIZATION, and is tried in order to find out about the recommended informal structure]

```
  If:   The recommended informal structure is known
  Then:  It is definite (1.0) that the following is the recommended
            informal structure: THE
            RECOMMENDED INFORMAL STRUCTURE TO USE IS <unkstruc>


  PREMISE:  ($AND (KNOWN CNTXT UNKSTRUC))
  ACTION:   (CONCLUDETEXT CNTXT UNKSTRUC (TEXT NIL
                      'THE
RECOMMENDED INFORMAL STRUCTURE TO USE IS'
                                             (VAL1 CNTXT UNKSTRUC))
                            TALLY 1000)
```

```
RULE035
-------
[This rule is definitional, applies to ORGANIZATION, and is tried
     when information is received about the recommended informal
     structure]

  If:  An attempt has been made to deduce the recommended informal
           structure
  Then:  Display the recommended informal structure


  PREMISE:  ($AND (ONCEKNOWN CNTXT UNKSTRUC t))
  ACTION:   (PRINTCONCLUSIONS CNTXT UNKSTRUC)

[ORGRULES/antecedent]


RULE036
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE TYPE OF SYSTEM RECOMMENDED TO BE USED, THETYPE OF
     OUTPUT DEVICE TO BE USED, THE RECOMMENDED INSTALLATION TO BE
     USED or THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED]

  If:  THE IMPLEMENTATION/CONSTRUCTION STATUS OF THE SYSTEM
  Then:  1) There is strongly suggestive evidence (.8) that THE TYPE
            OF SYSTEM RECOMMENDED TO BE USED is real-time,
         2) There is strongly suggestive evidence (.8) that THETYPE
            OF OUTPUT DEVICE TO BE USED is individual-terminals,
         3) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED INSTALLATION TO BE USED is pyramidal, and
         4) There is strongly suggestive evidence (.8) that THE
            RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED is
            train-existing-staff


  PREMISE:  ($AND (SAME CNTXT SYSSTAT YES))
  ACTION:   (DO-ALL (CONCLUDE CNTXT TYPSYS REAL-TIME TALLY 800)
                    (CONCLUDE CNTXT OUTPUT INDIVIDUAL-TERMINALS TALLY
                              800)
                    (CONCLUDE CNTXT INSTALL PYRAMIDAL TALLY 800)
                    (CONCLUDE CNTXT TRG train-existing-staff TALLY 800))

[ORGRULES]


RULE039
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE RECOMMENDED FORMAL STRUCTURE]

  If:  THE ORGANIZATION'S STRUCTURE is notavailable
  Then:  There is strongly suggestive evidence (.8) that THE
            RECOMMENDED FORMAL STRUCTURE is line


  PREMISE:  ($AND (SAME CNTXT FORMAL NOTAVAILABLE))
  ACTION:   (CONCLUDE CNTXT FORSTRUC LINE TALLY 800)
```

```
[ORGRULES]

RULE040
-------
[This rule applies to ORGANIZATION, and is tried in order to find out
     about THE RECOMMENDED FORMAL STRUCTURE]

  If:  THE RECOMMENDED FORMAL STRUCTURE is known
  Then:  It is definite (1.0) that the following is THE RECOMMENDED
            FORMAL STRUCTURE: THE RECOMMENDED FORMAL STRUCTURE TO USE
            IS <forstruc>


  PREMISE:  ($AND (KNOWN CNTXT FORSTRUC))
  ACTION:  (CONCLUDETEXT CNTXT FORSTRUC (TEXT NIL
                     'THE RECOMMENDED FORMAL STRUCTURE TO USE IS'
                                            (VAL1 CNTXT FORSTRUC))
                       TALLY 1000)

[ORGRULES]

RULE041
-------
[This rule is definitional, applies to ORGANIZATION, and is tried
     when information is received about THE RECOMMENDED FORMAL
     STRUCTURE]

  If:  An attempt has been made to deduce THE RECOMMENDED FORMAL
          STRUCTURE
  Then:  Display THE RECOMMENDED FORMAL STRUCTURE


  PREMISE:  ($AND (ONCEKNOWN CNTXT FORSTRUC t))
  ACTION:  (PRINTCONCLUSIONS CNTXT FORSTRUC)

[ORGRULES/antecedent]

NIL
-
```

APPENDIX F

EMYCIN/DECAIDS PREDICATE FUNCTIONS[1]

Non-Numeric Predicates

In all the predicates that use VALU, VALU may be omitted for yes/no paramters. If present, VALU may be an atom, a simple list, or a list of value-cf pairs. The predicates SAME and THOUGHTNOT return numbers which will be minimized by $AND to determining the setting of TALLY. The other predicates return true (or 1000) or false (NIL).

DEFINITE[CNTXT,PARM]
Returns true if PARM of CNTXT is known with certainty (cf = 1.0; for yes/no parameters, also cf = -1.0).
Ex: (DEFINITE CNTXT IDENT)
The identity of the organism is known with certainty

DEFIS[CNTXT,PARM,VALU]
Returns true if PARM of CNTXT is known with certainty to be VALU (cf = 1.0).
Ex: (DEFIS CNTXT IDENT MYCOBACTERIUM-TB)
It is definite that the identity of the organism is Mycobacterium-tb

DEFNOT[CNTXT,PARM,VALU]
Returns true if PARM of CNTXT is definitely not VALU (cf = -1.0).
Ex: (DEFNOT CNTXT IDENT VIRUS)
It is definite that the identity of the organism is not Virus

KNOWN[CNTXT,PARM]
Returns true if the value of PARM of CNTXT is known (cf > .2; for yes/no parameters, also cf < -.2).
Ex: (KNOWN CNTXT IDENT)
The identity of the organism is known

MIGHTBE[CNTXT,PARM,VALU]
True if PARM of CNTXT might be VALU, i.e. there is no evidence against it (cf > -.2).
Ex: (MIGHTBE CNTXT ADEQUATE)
There is no evidence that the dose of the drug was not appropriate

NOTDEFINITE[CNTXT,PARM]
Returns true if PARM of CNTXT is not known with certainty (cf < 1.0; for yes/no parameters, -1.0 < cf < 1.0).
Ex: (NOTDEFINITE CNTXT GENUS)
The genus of the organism is not known with certainty

NOTDEFIS[CNTXT,PARM,VALU]
Returns true if PARM of CNTXT is thought to be VALU, but not with certainty (.2 < cf < 1.0).
Ex: (NOTDEFIS CNTXT IDENT CRYPTOCOCCUS)
It is suspected that the identity of the organism is cryptococcus

NOTDEFNOT[CNTXT,PARM,VALU]
Returns true if PARM of CNTXT is thought not to be VALU, but not with certainty (-1.0 < cf < -.2).

[1]From the combined research of Roland, Buscemi and Masica.

Ex: (NOTDEFNOT CNTXT IDENT E.COLI)
It is suspected that the identity of the organism is not E.coli

NOTKNOWN[CNTXT,PARM]
Returns true if PARM of CNTXT is not known (cf <= .2; for yes/no parameters, -.2 <= cf <= .2).
Ex: (NOTKNOWN CNTXT IDENT)
The identity of the organism is not known

NOTSAME[CNTXT,PARM,VALU]
The logical compliment of SAME, returns true if PARM of CNTXT is not thought to be VALU (cf <= .2).
Ex: (NOTSAME CNTXT SPECSTAIN)
Organisms were not seen on the stain of the culture

ONCEKNOWN[CNTXT,PARM,RETFLG]
Finds the value of PARM of CNTXT. If RETFLG is NIL, it means "you have found a value for PARM of CNTXT"; returns the same as KNOWN would. If RETFLG is T, it means "find out all you can about PARM of CNTXT"; this causes tracing, but ONCEKNOWN will return true even if nothing was found

out. Intended to be invoked last among the updated-by rules of PARM.
Ex: (ONCEKNOWN CNTXT SAMEBUG)
There is an organisms with possibly the same identity as this organism

ONCEKNOWN*[CNTXT,PARMS]
Traces PARMS of CNTXT and returns T regardless of the result of this tracing. This is like calling ONCEKNOWN repeatedly, once for each parameter in PARMS, with RETFLG set to T in the calls.
Ex: (ONCEKNOWN* CNTXT (QUOTE (CURTHER PRIORTHER)))
Information has been gathered about current drugs of the patient and prior drugs of the patient

SAME[CNTXT,PARM,VALU]
Checks to see if PARM of CNTXT is VALU returning the associated cf. Always returns a number; in a rule, $AND will consider the clause "true" if this number greater than .2.
Ex: (SAME CNTXT SITE BLOOD)
The site of the culture is blood

THOUGHTNOT[CNTXT,PARM,VALU]
Checks to see if PARM of CNTXT is not VALU, i.e., there is evidence against it. Always returns a number; in a rule, $AND will consider the clause "true" if this number greater than .2. The number that is returned is the negative of the cf associated with the triple (CNTXT PARM VALU), so the clause will be true if the cf associated with that triple is less than -.2. This is the algebraic negation of SAME, whereas NOTSAME is the logical negation.
Ex: (THOUGHTNOT CNTXT IDENT E.COLI)
There is evidence that the identity of the organism is not E.coli

VNOTKNOWN[CNTXT,PARM,VALU]
Returns true if it is not known whether the value of PARM of CNTXT is (or is not) VALU (-.2 <= cf <= .2).
Ex: (VNOTKNOWN CNTXT IDENT E.COLI)
It is not known whether the identity of the organism is E.coli

Numeric predicate functions

There are five numeric predicate functions to be used with parameters which take numbers or dates as their values. A parameter with DATE for its EXPECT property accepts a date as input, but internally stores the answer as the number of days ago (or since the time of the original consultation for stored cases). The Lisp functions PLUS, DIFFERENCE, MINUS, TIMES, FQUOTIENT, and EXPT have translations in case they are used within these numeric predicates. The translations of numeric expressions can be very wordy. To have an expression translated tersely (using arithmetic operator symbols instead of text), enclose the expression in a call to the function TRSEXP.

BETWEEN*[VALU,LLIM,ULIM]
True if LLIM <= VALU < ULIM
Ex: (BETWEEN* (VAL1 CNTXT AGE) 10 50)
The age of the patient is between 10 years and 50 years

GREATEQ*[X,Y]
True if X and Y are numbers and X >= Y.
Ex: (GREATEQ* (VAL1 CNTXT NUMPOS) 2)
The number of cultures from this site which were positive for this organism is greater than or equal to 2

GREATERP*[X,Y]
True if X and Y are numbers and X > Y.
Ex: (GREATERP* (VAL1 CNTXT CSFGLUC) 80)
The csf glucose value is greater than 80

LESSEQ*[X,Y]
True if X and Y are numbers and X <= Y.
Ex: (LESSEQ* (VAL1 CNTXT CSFGLUC) 80)
The csf glucose value is less than or equal to 80

LESSP*[X,Y]
True if X and Y are numbers and X < Y.
Ex: (LESSP* (VAL1 CNTXT CSFGLUC) 80)
The csf glucose value is less than to 80

Conclusion Functions

The functions in a rule's ACTION concludes about one or more context-parameter-value triple. A cf for the triple is specified in the rule's ACTION. This cf will be modified by the certainty of the rule's PREMISE. $AND sets TALLY to the certainty of the PREMISE, defined to be the minimum of the values (numbers) returned by evaluating the PREMISE clauses (only SAME and THOUGHTNOT return numbers).

If a triple already exists, this new cf is 'combined' with the cf associated with that triple. Otherwise, the new cf itself is associated with the new triple.

CONCLUDE[CNTXT,PARM,VALUE,TALLY,NUM]
Concludes that PARM of CNTXT is VALUE. The conclusion made by this call will have a cf that is TALLY times NUM.

```
Ex:     (CONCLUDE CNTXT CONTAMINANT YES TALLY 400)
        There is weakly suggestive evidence (.4) that the organism is a
                 contaminant
```

CONCLUDE*[CNTXT,PARM,TALLY,VALS]
Performs multiple CONCLUDE's for a single CNTXT and PARM. VALUS is a list of pairs (value cf); each value is concluded with the corresponding

cf.

```
Ex:     [CONCLUDE* CNTXT IDENT TALLY (QUOTE ((E.COLI 400)
                                             (KLEBSIELLA-PNEUMONIAE 300)
                                             (PROTEUS-MIRABILIS 300]
        There is evidence that the identity of the organism is e.coli (.4)
                 klebsiella-pneumoniae (.3) proteus-mirabilis (.3)
```

CONCLUDET[CNTXT,SWITCHNUM,CASE,TALLY,PARM,VALUS]
Tabular rule concluding fn. Concludes that PARM of CNTXT is one or more of the values in VALUS, according to the value of SWITCHNUM.

SWITCHNUM is a form to evaluate which must return a number. It is generally a call to VAL1 for some numeric parameter.

VALUS is a list (VAL1 VAL2 ... VALn) of values for PARM.

CASE is a list of cases which test SWITCHNUM and supply cfs for the values in VALUS that is to be concluded. Possible cases currently are:

```
(LT NUM CF1 CF2 ... CFn)  if SWITCHNUM < NUM, conclude that  PARM is
        VALi with cf CFi;
(BT NUM1 NUM2 CF1 CF2 ... CFn) if NUM1 <= SWITCHNUM < NUM2, conclude
        that PARM is VALi with cf CFi;
(GE NUM CF1 CF2 ... CFn) if NUM <= SWITCHNUM, conclude that PARM
        is VALi with cf CFi;
(U CF1 CF2 ... CFn) if SWITCHNUM = NIL, conclude that PARM is
        VALi with cf CFi;
```

Each CFi must be included in each case; if a particular value doesn't apply, the corresponding cf can be 0.

```
Ex:     (CONCLUDET CNTXT (VAL1 CNTXT LENSIGN)
             (QUOTE ((BT 9 13 -400 -500)
                     (BT 13 20 -500 -400)
                     (GE 20 600 300)))
             TALLY TYPE (QUOTE (BACTERIAL VIRAL)))
The type of the infection is as follows:
   If the duration of the neurological signs is:
   a) between 9 days and 13 days then: not bacterial (.4), not viral (.5);
   b) between 13 days and 20 days then: not bacterial (.5), not viral (.4);
   c) greater or equal to 20 days then: bacterial (.6), viral (.3);
```

CONCLUDETEXT[CNTXT,PARM,VALUE,TALLY,NUM]

This function calls CONCLUDE for parameters whose values are arbitrary peices of text. It is a different function because it translates differently.

DO-ALL[X] NL*

For multiple conclusions - evaluates each of its arguments (rule conclusions).

Ex: (DO-ALL (CONCLUDE CNTXT IDENT LISTERIA TALLY 500)
(CONCLUDE CNTXT GENUS CORYNEBACTERIUM TALLY 500)

1) There is suggestive evidence (.5) that the identity of the organism is Listeria, and
2) There is suggestive evidence (.5) that the genus of the organism is Corynebacterium

DONTASK[CNTXT,PARM]

Conclusion function which says that PARM of CNTXT should not be asked (although it may be traced, if needed).

Ex: (DONTASK CNTXT CONFORM)
Don't ask about the growth conformation of the organism

NOTRELEVANT[CNTXT,PARMS,CF]

A conclusion function that indicates that the value of each of the parameters in PARMs is not relevant for CNTXT: we shouldn't ever ask or try rules to deduce the value.

Ex: (NOTRELEVANT CNTXT (QUOTE (SECONDARY)) 1000)

It is definite (1.0) that the following is irrelevant: the infection to which the bacteremia is secondary

PRINTCONCLUSIONS[CNTXT,PARM,HEADER]

Displays nicely the value of PARM of CNTXT, or indicates that no conclusions were made. Intended as a simple goal rule ACTION. If HEADER is T, prefixes values with a simple header announcing what these are the values of; if other non-NIL value, HEADER is printed; otherwise no header at all is printed, and nothing is mentioned if there are no values.

Special facility for use with TEXT-valued parms: if PARM has a property LABEL.ORDER, then TEXT values of equal cf will be sorted by their labels. For LABEL.ORDER=T, the labels are integers, and the values will be sorted in ascending order of label; otherwise the LABEL.ORDER property is a list of labels (atoms), and the values are sorted according to the order of the labels in this list.

Ex: (PRINTCONCLUSIONS CNTXT REGIMEN)
Display the therapeutic regimen of the patient

Auxilliary functions

$AND[$$CLAUSES] NL*

Evaluates each of the predicates in $$CLAUSES until one fails; if all succeed (i.e. return T or a cf > .2) the minimum cf is returned, else NIL. All rule premises and the predicates of all mapping functions must be calls to $AND - even if there is only a single predicate clause inside the $AND.

$OR[$$CLAUSES] NL*
Evaluates each of the predicates in $$CLAUSES, returning the c.f. of the most highly confirmed clause, unless all fail. Stops if one of the clauses evaluates with certainty (since the maximum 1.0 is the result).

```
Ex:        ($OR (GREATERP* (VAL1 CNTXT WBC) 12.5)
                (GREATERP* (VAL1 CNTXT PMNS) 80)
                (GREATERP* (VAL1 CNTXT BANDS) 10))
```

1) The white count from the patient's peripheral CBC (in thousands) is greater than 12.5, or
2) The percent of PMN's in the CBC is greater than 80, or
3) The percent of peripheral WBC's which are immature in the CBC is greater than 10

LISTOF[N] L*
Simply EVALs its argument (which is usually the name of a list). Used as argument to a basic predicate when a choice of values is indicated.

```
Ex:     (SAME CNTXT SITE (LISTOF STERILESITES))
```

The site of the culture is one of: those sites that are normally sterile

ONEOF[X] NL*
A no-spread quote: returns its argument list. Used as argument to a basic predicate when a choice of values is indicated.

```
Ex:     (SAME CNTXT SITE (ONEOF URINE SPUTUM))
```

The site of the culture is one of: urine sputum

QUOTE[X] NL*
Lisp function. It is used in action functions that require a list of parameters, values, etc. (e.g., CONCLUDET).

TEXT[N] L*
Constructs value of TEXT-valued parms. The first argument is a label (or NIL) which may be used to tag the value for sorting by PRINTCONCLUSIONS. The remaining args are arbitrary rule forms to construct a text phrase. Result is a list (TEXT label . phrase). If there is only one arg, the label is interpreted as a TEXT tag, i.e. (TEXT label) is the same as (TEXT label (TEXTAG label)).

TEXTAG[TAG] NL
Quotes a text "tag", a place holder for a string of text which is the "value" of a conclusion parameter. TAG should be in PROP-TEXT, and should have a TRANS which is the string in question (at least in current implementation).

UNITS[U] NL*
Returns its first argument. The second argument is not seen by the function, but is a unit and is used for translation.

```
Ex:     (GREATERP* (VAL1 CNTXT AGE) (UNITS 3 YEARS))
```

The age of the patient is greater than three years

VAL[CNTXT,PARM]
Returns PARM of CNTXT as a list of pairs (value cf), tracing the parameter first if it has not been traced yet.

VAL1[ATM,PARM] NL

Returns the value of PARM of ATM, without its cf. Only suitable for single-valued parameters. ATM is evaluated, PARM is not.

VALYEW[CNTXT,PARM]

Returns PARM of CNTXT as a list of pairs (value cf) in order of decreasing cf. This is the same as returned by VAL if the parameter has already been traced. VALYEW causes no tracing; it can be interpreted as the system's current information about PARM of CNTXT

Mapping functions

You probably won't need to use mapping functions in any of your rules. The exist to allow a rule to use parameters of the context to which the rule is applied, as well as parameters of each of a specified list of contexts.

The functions map over a list $$MAPSET which is usually a list of contexts. $$FREEVAR is the name of the iteration variable; it is not necessary to specify a value for $$FREEVAR, the default FREEVAR will be used if none is specified. $$PRED is a predicate which has the same form as a rule PREMISE. Clauses in $$PRED may use CNTXT (the context to which the rule is being applied) as well as FREEVAR in their context slot. If $$MAPSET is a list of pairs (which it will be if the set is the result of a call to GETALL or GETOFFSPRING), the CARS flag should be set to T. This indicates that each time $$FREEVAR should be set to the CAR of the current element rather than the element itself. Most of the functions return $$ANSET set to their result. For functions whose result is a list, COLLECTEDLST is the default for $$ANSET; for those that return a single element, the default is FOUNDVAR. These result variables are global; the result of a mapping function in a rule's PREMISE is often used in that rule's ACTION.

A mapping function can be embedding in a call to the LISP function NOT, and the action and translations will be appropriatly negated.

FINDMAX[$$MAPSET,$$PRED.$$TEST,$$FREEVAR,$$ANSET,CARS] NL

Mapping function that returns $$ANSET set to the element of $$MAPSET which had the largest value of $$TEST out of all those elements which satisfied $$PRED. Global MAXVAL is set to this maximum value of $$TEST.

```
Ex:  .  (FINDMAX (GETALL CURTHER)
                 ($AND (KNOWN $FREEDRUG WHENSTART))
                 (VAL1 $FREEDRUG WHENSTART)
                 $FREEDRUG NIL T)
```

You have examined the current drugs of the patient for which the time since therapy with this drug was started is known, and have selected the one having the maximum value for the time since therapy with this drug was started

```
FINDMIN[$$MAPSET,$$PRED,$$TEST,$$FREEVAR,$$ANSET,CARS] NL
    Like FINDMAX, but looks for the the smallest value of $$TEST, and sets
global MINVAL.
Ex:     (FINDMIN (GETALL PRIORTHER)
                 ($AND (LESSEQ* (VAL1 $FREEDRUG WHENSTOP) 5))
                 (VAL1 $FREEDRUG WHENSTOP)
                 $FREEDRUG NIL T
        You have examined the prior drugs of the patient for which the
                 time since therapy with this drug was discontinued is less
                 than or equal to 5 days, and have selected the one having
                 the minimum value for the time since therapy with this
                 drug was discontinued

FORALL[$$MAPSET,$$PRED,$$FREEVAR,CARS] NL
    True if $$PRED is true for each element of $$MAPSET. Function returns
(trivially) true if map set is empty.
Ex:     (FORALL (GETALL POSCUL) ($AND (NOTSAME FREEVAR SPECSTAIN)
                                      (NOTSAME FREEVAR CRYPTO-SEROLOGY)
                                      (NOTSAME FREEVAR COCCI-SEROLOGY)))
        For each of the the positive cultures of the patient it is true that
                 1) Organisms were not seen on the stain of this culture,
                 2) The cryptococcal antigen in the csf was not positive, and
                 3) The csf coccidioides serology was not positive

THEREARE[$$MAPSET,$$PRED,$$FREEVAR,$$ANSET,CARS,DUPLES] NL
    Collects all the elements of $$MAPSET for which $$PRED is true.
If DUPLES is T, it returns a list of duples pairing each element
of $$MAPSET that succeeded with the value (number) returned when
the predicate was appliedto that element.
Ex:     (THEREARE (GETALL KNOWNORG)
                 ($AND (DEFINITE CNTXT IDENT))
                 NIL COLLECTEDORGS T)
        You have examined the organisms isolated from positive cultures
                 obtained from the patient, selecting those for which the
                 identity of the organism is known with certainty

THEREARE![N] L*
    Returns true if LST is non-empty.  This is like a call to THEREARE with
$$MAPSET T, but translates better.
Ex:     (THEREARE! (GETOFFSPRING CNTXT SMEARORG))
        There are organisms noted on smears of this culture

THEREXISTS[$$MAPSET,$$PRED,$$FREEVAR,$$ANSET,CARS] NL
    Like THEREARE, but just finds the FIRST element (or CAR of element)
satisfying $$PRED, and returns that.
Ex:     (THEREXISTS (GETALL CURTHER)
                 ($AND (SAME FREEVAR DNAME (ONEOF AMPICILLIN CARBENICILLIN
                                                  PENICILLIN METHICILLIN)))
                 NIL NIL T)
        You have examined current drugs of the patient, and have found one
                 for which the name of this drug is one of: ampicillin
                 carbenicillin penicillin methicillin
```

Functions used within Mapping Functions

GETALL[CTYPE] NL

Returns a list of all contexts of type CTYPE. Currently in the form ((cntxt 1000)...), until we get around to being neater. This is often used in the $$MAPSET slot.

GETOFFSPRING[CNTXT,TYPE]

Returns a list of contexts of type TYPE descendant to CNTXT Currently a list ((cntxt 1000) ...).

APPEND[L] L*

Lisp function. It is used in the $$MAPSET slot when more than one type of context is to be examined.

NOTSAMEANS[CNTXT1,CNTXT2,PARM]

Premise clause which is true if CNTXT1 and CNTXT2 have different values [illegible]

SAMEANS[CNTXT1,CNTXT2,PARM]

A premise function that is true if CNTXT1 and CNTXT2 have the same value for parameter PARM.

TRACEDP[CNTXT,PARM]

True if PARM has been traced for CNTXT. This is used when the value of a parameter of one context is to be transfered to another context. To avoid circular reasoning, we specify that the target parameter must

already be traced for a context to satisfy the predicate.

```
Ex:     (THEREXISTS (APPEND (GETALL POSCUL) (GETALL PENDCUL))
                    ($AND   (TRACEDP FREEVAR NOSOCOMIAL)
                            (KNOWN FREEVAR NOSOCOMIAL)
                            (SAMEANS CNTXT FREEVAR SITE))
                    NIL FOUNDCUL T)
        You have examined positive cultures obtained from the patient and
                    pending cultures of the patient, and have found one for which
                    1) All information about whether the infection was
                            acquired while the patient was hospitalized has
                            been gathered, and
                    2) It is known whether the infection was acquired while
                            the patient was hospitalized, and
                    3) The culture under consideration and this culture have the
                            same value for the site of the culture
```

Action Functions used in Rules with Mapping Functions

CONCLIST[CNTXT,PARM,GVAL,TALLY]

GVAL is a list of duples (value cf). Concludes that PARM of CNTXT is each of those values, modified by TALLY.

```
Ex:     (CONCLIST CNTXT IDENT GRIDVAL 900)
        There is strongly suggestive evidence (.9) that each of the ones
                    that you found is the identity of the organism
```

CONCLUDEALL[CNTXTS,PARM,VALU,CF]

Makes the same conclusion for each of a list of contexts.

```
Ex:     (CONCLUDEALL COLLECTEDCULS REQTHER YES -1000)
        It is definite (1.0) that the organisms isolated from the cultures
                    that you selected should not be considered for therapy
```

TRANSDIFPARM[FROM!,FPARM,TO!,TPARM,CF,POSITIVE]

Transfers the value of FPARM of FROM! to TPARM of TO!, modified by CF. Either FROM! or TO! may be a list of contexts or a single context. FPARM and TPARM are different parameters. If POSITIVE is set, it only transfers values with non-negative CFs.

Ex: (TRANSDIFPARM COLLECTEDORGS IDENT CNTXT COVERFOR 700)

There is suggestive evidence (.7) that the identity of each of the organisms that you selected is the organisms (other than those seen on cultures or smears) which might be causing the infection

TRANSLIST[FROM,TO,PARMS,I]

Transfers to context TO the values of of each of the PARMS of the contexts in FROM, modifying the cf's by I.

Ex: (TRANSLIST (VALYEW CNTXT SAMEBUG) CNTXT (QUOTE (IDENT)) 1000)

It is definite (1.0) that these properties - ident - should be transferred from the organisms with possibly the same identity as this organism to this organism

TRANSPARM[FROM!,TO!,PARM,CF]

Transfers the value of PARM of FROM! to TO!, modified by CF. Either FROM! or TO! may be a list of contexts or a single context. If POSITIVE is set, only transfers values with non-negative CFs.

Ex: (TRANSPARM FOUNDCUL CNTXT SECONDARY 1000)

It is definite (1.0) that the information that you have gathered about the infection to which the bacteremia is secondary is also relevant to this culture

APPENDIX G

DECAIDS PARAMETER LISTING[1]

```
DECAIDS  ORG                 METHODS  ORG              STRESS  ORG
ENVIRONMENT  ORG             ORGANIZATION  VAL         STYLE  ORG
FORMAL  ORG                  ORGRULES  ALLNAMES        SYSSTAT  ORG
FORSTRUC  ORG                OUTPUT  ORG               TRAINING  ORG
INFORMAL  ORG                PROBDEF  ORG              TRG  ORG
INSTALL  ORG                 PROBTYPE  ORG             TYPSYS  ORG
KNOWLEDGE-LEVEL  ORG         STAFF  ORG                UNKSTRUC  ORG
LEADER-TRAINING  ORG         STFFTRG  ORG
                                  PROP-ORG
                                  --------

DECAIDS
-------
  ANTECEDENT-IN:  (RULE001)
  UPDATED-BY-THE-WAY:  (RULE001)
  UPDATED-BY:  (RULE002)
  TRANS:  (THE DECISION)
  LEGALVALS:  TEXT
  MULTIVALUED:  T

ENVIRONMENT
-----------
  TRANS:  (*'s ENVIRONMENT)
  PROMPT:  (WILL YOU COMMENT ON THE LEADER-TRAINING OR THE
                STAFF-TRAINING OF THE ENVIRONMENT OF THE ORGANIZATION?)
  EXPECT:  (LEADER-TRAINING STAFF-TRAINING)
  LABDATA:  T

FORMAL
------
  USED-BY:  (Rules 39 32 31 30 17 16)
  TRANS:  (THE ORGANIZATION'S STRUCTURE)
  PROMPT:  (THE FORMAL STRUCTURE OF THE ORGANIZATION CAN BE DEFINED AS
              EITHER LINE, STAFF, MATRIX, FUNCTIONAL, OR
              NOTAVAILABLE. IF FURTHER EXPLANATION OF THESE TERMS IS
              NEEDED, TYPE A QUESTION MARK. WHAT IS THE
              ORGANIZATION'S FORMAL STRUCTURE?)
  EXPECT:  (LINE STAFF FUNCTIONAL MATRIX NOTAVAILABLE)
  LABDATA:  T
  REPROMPT:  (LINE - EMPHASIZES DIRECT CHAINS OF AUTHORITY AND UNITY OF
                 COMMAND STAFF - INCLUDES AN INFORMATIONAL AND
                 ADVISORY STAFF TO ASSIST AND GUIDE OPERATIONAL
                 PERSONNEL FUNCTIONAL - ARRANGES PERSONNEL BY
                 FUNCTIONAL ACTIVITY SUCH AS LOGISTICS,
                 COMMUNICATIONS, ETC. MATRIX - DRAWS PERSONNEL FROM
                 ACROSS DEPARTMENTAL LINES)

FORSTRUC
--------
  UPDATED-BY:  (Rules 39 SREFMARK 40)
  USED-BY:  (RULE040)
  CONTAINED-IN:  (RULE040)
  ANTECEDENT-IN:  (RULE041)
  UPDATED-BY-THE-WAY:  (RULE041)
  TRANS:  (THE RECOMMENDED FORMAL STRUCTURE)
  EXPECT:  (LINE STAFF FUNCTIONAL MATRIX)
```


[1]From the combined research of Roland, Buscemi and Masica.

```
INFORMAL
--------
  USED-BY:  (Rules 33 22 21 19 18 15 3)
  TRANS:  (THE ORGANIZATION'S STRUCTURE)
  PROMPT:  (THE INFORMAL STRUCTURE OF THE ORGANIZATION REFERS TO THE
                 MANNER IN WHICH COMMUNICATION IS ACCOMPLISHED. IS THE
                 INFORMAL STRUCTURE BEST DESCRIBED AS CENTRALIZED,
                 CONSULTATIVE, TRANSACTIONAL, PARTIALLY-DELEGATED,
                 DECENTRALIZED, OR NOTAVAILABLE ? IF FURTHER EXPLANATION
                 IS NEEDED, TYPE A QUESTION MARK.)
  EXPECT:  (CENTRALIZED CONSULTATIVE TRANSACTIONAL PARTIALLY-
                DELEGATED DECENTRALIZED NOTAVAILABLE)
  LABDATA:  T
  REPROMPT:  (CENTRALIZED - USES A FOCUSED FLOW OF AUTHORITY TO A
                  SINGLE SOURCE AT THE TOP OF THE HIERARCHY
                  CONSULTATIVE - MAXIMIZES PATTERNS OF CENTRAL CONTROL
                  BUT ENCOURAGES VERTICAL AND UPWARD COMMUNICATION OF
                  ADVICE AND GUIDANCE FROM A PROFESSIONAL STAFF
                  TRANSACTIONAL - STRESSES OPEN COMMUNICATION,
                  DELIBERATION, AND NEGOTIATION, BOTH LATERALLY WITHIN
                  LEVELS AND VERTICALLY AMONG LEVELS.  AUTHORITY MAY
                  STILL REMAIN AT/WITH TOP MANAGEMENT PARTIALLY-
                  DELEGATED - DISTRIBUTES AUTHORITY AMONG PROFESSIONAL
                  STAFF WHILE INCREASING THE NEED FOR CO-ORDINATION OF
                  EFFORT.  THE STAFF MAY POSSESS AUTHORITY TO DEVELOP
                  ACTION ALTERNATIVES BUT TOP MANAGEMENT STILL RETAINS
                  THE RIGHT TO REJECT AND MODIFY DECENTRALIZED -
                  DELEGATES AND DISPERSES FULL DECISION-MAKING POWER
                  TO STAFF AT LOWER LEVELS OF THE HIERARCHY)

INSTALL
-------
  USED-BY:  (RULE002)
  CONTAINED-IN:  (RULE002)
  UPDATED-BY:  (Rules 36 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18
                  17 16 15 14 13 9 8 7 6 5 4 3)
  TRANS:  (THE RECOMMENDED INSTALLATION TO BE USED)
  EXPECT:  (PYRAMIDAL DIVISIONAL UNAVAILABLE)
  REPROMPT:  (A divisional installation places authority in each
                 division for independent systems while pyramidal
                 installations place authorityat the top of one
                 super-system above all divisions.)

KNOWLEDGE-LEVEL
---------------
  USED-BY:  (Rules 29 28)
  TRANS:  (the technological knowledge-level)
  PROMPT:  (IN REGARDS TO THE TECHNOLOGICAL TRAINING REQUIRED TO
                ACCOMPLISH THE TASK, IS THE LEVEL OF TECHNICAL TRAINING
                CONSIDERED TO BE SKILLED, UNSKILLED, OR UNKNOWN?)
  EXPECT:  (SKILLED UNSKILLED)
  LABDATA:  T

LEADER-TRAINING
---------------
  USED-BY:  (Rules 5 4)
  TRANS:  (THE LEADER'S LEVEL OF TRAINING)
  PROMPT:  (Is the task leader's technical training considered to be
                skilled, unskilled, or unknown?)
  EXPECT:  (SKILLED UNSKILLED)
  LABDATA:  T
```

```
METHODS
-------
  USED-BY:  (Rules 27 26)
  TRANS:  (THE TECHNOLOGICAL METHODS AVAILABLE)
  PROMPT:  (ARE THE TECHNOLOGICAL METHODS USED ANALYTICAL-AIDS,
                INVENTORY-AIDS, OR UNKNOWN?)
  EXPECT:  (ANALYTICAL-AIDS INVENTORY-AIDS)
  LABDATA:  T
  REPROMPT:  (Inventory aids refer to administrative uses and
                 analytical aids are those which concern scientific
                 applications.)

OUTPUT
------
  USED-BY:  (RULE002)
  CONTAINED-IN:  (RULE002)
  UPDATED-BY:  (Rules 36 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18
                   17 16 15 14 13 9 8 7 6 5 4 3)
  TRANS:  (the type of output device to be used)
  EXPECT:  (INDIVIDUAL-TERMINALS LARGE-SCREEN-DISPLAYS UNAVAILABLE)

PROBDEF
-------
  USED-BY:  (Rules 14 13)
  TRANS:  (THE TASK DEFINITION)
  PROMPT:  (CONCERNING THE PROBLEM FACING THE ORGANIZATION, IS THE
               PROBLEM CLEARLY-DEFINED, AMBIGUOUS, OR UNKNOWN?)
  EXPECT:  (CLEARLY-DEFINED AMBIGUOUS)
  LABDATA:  T

PROBTYPE
--------
  TRANS:  (THE TYPE OF PROBLEM TO BE SOLVED)
  PROMPT:  (THIS PROGRAM IS DESIGNED TO PROVIDE MANAGERS AT ALL LEVELS
                 WITH ADVICE CONCERNING THE USE OF THEIR COMPUTER
                 RESOURCES. IN ORDER TO PROVIDE THIS INFORMATION, THE
                 USER WILL BE ASKED TO FURNISH DATA CONCERNING HIS
                 ORGANIZATION, ITS LEVEL OF TRAINING, THE
                 ORGANIZATION'S LEADER, THE ENVIRONMENT AFFECTING THE
                 DECISION, AND THE TASK FACING THE ORGANIZATION. WHAT
                 IS THE TYPE OF PROBLEM WHICH THE ORGANIZATION FACES?)
  EXPECT:  ANY
  LABDATA:  T

STAFF
-----
  TRANS:  (THE FORMAL COMPOSITION OF THE ORGANIZATION'S STRUCTURE)
  PROMPT:  (IS THE STAFF'S TECHNICAL TRAINING SKILLED, UNSKILLED, OR
               UNKNOWN?)
  EXPECT:  (SKILLED UNSKILLED)
  LABDATA:  T

STFFTRG
-------
  USED-BY:  (Rules 7 6)
  TRANS:  (THE STAFF'S LEVEL OF TECHNICAL TRAINING)
  PROMPT:  (IS THE ORGANIZATION'S STAFF'S LEVEL OF TECHNICAL TRAINING
               IN THE USE OF COMPUTERIZED TECHNICAL AIDS CONSIDERED
               SKILLED, UNSKILLED, OR UNKNOWN?)
  EXPECT:  (SKILLED UNSKILLED)
  LABDATA:  T
```

```
STRESS
------
  USED-BY:  (Rules 9 8)
  TRANS:  (THE LEVEL OF THE TASK'S STRESS)
  PROMPT:  (IS THE STRESS LEVEL CONSIDERED TO BE HIGH, LOW, OR UNKNOWN?)
  EXPECT:  (HIGH LOW)
  LABDATA:  T

STYLE
-----
  USED-BY:  (Rules 23 20)
  TRANS:  (THE LEADER'S STYLE OF OPERATION)
  PROMPT:  (IS THE TASK LEADER'S STYLE BEST DESCRIBED AS
            RELATION-ORIENTED,TASK-ORIENTED, OR UNKNOWN?)
  EXPECT:  (RELATION-ORIENTED TASK-ORIENTED)
  LABDATA:  T
  REPROMPT:  (relation oriented refers to the leader who gives little
              direction to his staff, encourages the staff to
              actively participate in setting decision making
              parameters, and values the development of personnel
              responsibility.  Task oriented leaders are defined
              as those who prefer far more centralization of
              control and are less concerned with the development
              of individual responsibility in the decision making
              process.)

SYSSTAT
-------
  USED-BY:  (RULE036)
  TRANS:  (THE IMPLEMENTATION/CONSTRUCTION STATUS OF THE SYSTEM)
  PROMPT:  (DOES AN OPERATIONAL SYSTEM CURRENTLY EXIST?)
  EXPECT:  (YES NO)
  LABDATA:  T

TRAINING
--------
  USED-BY:  (Rules 25 24)
  TRANS:  (THE INDIVIDUAL'S TECHNICAL TRAINING IN DECISION ANALYSIS)
  PROMPT:  (IS THE TASK LEADER'S LEVEL OF TECHNICAL TRAINING CONSIDERED
            TO BE HIGH, LOW, OR UNKNOWN?)
  EXPECT:  (HIGH LOW)

TRG
---
  USED-BY:  (RULE002)
  CONTAINED-IN:  (RULE002)
  UPDATED-BY:  (Rules 36 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18
                17 16 15 14 13 9 8 7 6 5 4 3)
  TRANS:  (THE RECOMMENDED TRAINING OR ASSISTANCE TO BE ACQUIRED)
  EXPECT:  (HIRE-SPECIALISTS DO-NOT-HIRE-SPECIALISTS TRAIN-EXISTING-
            STAFF UNAVAILABLE)

TYPSYS
------
  USED-BY:  (RULE002)
  CONTAINED-IN:  (RULE002)
  UPDATED-BY:  (Rules 36 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18
                17 16 15 14 13 9 8 7 6 5 4 3)
  TRANS:  (THE TYPE OF SYSTEM RECOMMENDED TO BE USED)
  EXPECT:  (REAL-TIME NON-REAL-TIME UNAVAILABLE)
```

```
UNKSTRUC
--------
  UPDATED-BY:  (Rules 33 SREFMARK 34)
  USED-BY:  (RULE034)
  CONTAINED-IN:  (RULE034)
  ANTECEDENT-IN:  (RULE035)
  UPDATED-BY-THE-WAY:  (RULE035)
  TRANS:  (the recommended informal structure)
  EXPECT:  (CENTRALIZED DECENTRALIZED CONSULTATIVE TRANSACTIONAL
               PARTIALLY-DELEGATED)
^LPROP-VAL                                    :
^XPROP-VAL
                                        PROP-VAL
                                        --------

ORGANIZATION
------------
  TRANS:  (THE ORGANIZATION)
  MAINPROPS:  (PROBTYPE FORMAL INFORMAL STFFTRG LEADER-TRAINING STYLE
                  PROBDEF KNOWLEDGE-LEVEL STRESS SYSSTAT METHODS)
  PROPTYPE:  PROP-ORG
  TYPE:  ORGANIZATION-
  RULETYPES:  (ORGRULES)
  GOALS:  (DECAIDS UNKSTRUC FORSTRUC)
^LALLNAMES
^XALLNAMES
                                        ALLNAMES
                                        --------

ORGRULES
--------
  CONTEXT:  (ORGANIZATION)
  SVAL:  (ORGANIZATION)
  CTRANS:  ORGANIZATION
NIL
-
```

APPENDIX H

ADDITIONAL EMYCIN/DECAIDS PARAMETER PROPERTIES[1]

Defining Contexts

MAINPROPS - a list of parameters to "trace" when a context of this type is created. Generally these are labdata parameters whose values will always be needed in a consultation (see PARAMETERS.DOC for a definition of "labdata"). The user will be asked for the value of each of these parameters as soon as a context is created. This often serves to present a more coherent dialog than would appear if each parameter were requested when it was first needed in a rule. It is also possible to have non-labdata parameters for mainprops if there is always something you want to deduce about a new context. The goal parameter(s) of a system will be found in the MAINPROPS list of the main (or root) context type; its placement here is what gets the consultation started.

PROPTYPE - an atom PROP-type which lists all parameters which pertain to this type of context, e.g., the PROPTYPE of PERSON in MYCIN is PROP-PT, which contains such parameters as NAME, AGE, SEX, etc. When applying a rule, the system uses this property to tell which context in the tree a particular parameter belongs to.

TYPE - an atom used to form the context identifier (by appending a numeral) for contexts of this type, e.g., in MYCIN the TYPE of POSCUL (positive culture) is CULTURE-.

RULETYPES - a list of all rule types applicable to this context (see RULES.DOC), e.g., RULETYPES of POSCUL is the list (CULRULES POSCULRULES).

SYN - a template used for translating contexts of this type in questions or rules. The SYN property is a list of entries (<parms> <form>), where <parms> is a list of one or more parameters of the context, and <form> is a simple list of words including the elements of <parms>. The parameters must appear in the same order in both <parms> and <forms>, and they must all be labdata. The atom * is used like a parameter in <parms> and <form> to represent the parent context.

The system scans the SYN property until it finds an entry for which it knows the values of all parameters in <parms>; values which were not supplied by the user will not be used. Once an element of SYN has been selected, a translation will be constructed by replacing each parameter in <form> with that parameter's value; * will be replace by the translation (using the SYN property) of the parent context. <parms> and <form> may be punctuated with semicolons denoting "places to stop" if the translation is unambiguous so far. E.g., the element from the SYN property of an organism ((IDENT ; *) (the IDENT ; from *)) will result in "the Klebsiella" if there are no other organisms whose IDENT is Klebsiella, and "the Klebsiella from the blood culture" if there is.

The simplest SYN is of the form (((parm)(parm))), i.e., there is a parameter of the context whose value itself can stand

[1] From the combined research of Roland, Buscemi and Masica.

for the context, e.g., (((NAME) (NAME))). If there is no SYN prop, the context identifier (e.g., ORGANISM-1) will remain untranslated.

UNIQUE - For use in conjunction with the SYN prop: it controls whether the context identifier needs to appear in the translation, e.g. a typical non-unique phrase is 'the blood culture (CULTURE-2)', since it is possible to have more than one culture from the same site. If the UNIQUE property is T, the context identifier is omitted, e.g., the root context type should have its UNIQUE property T. If UNIQUE is the atom '?', this means to omit the identifier if the first try at translating the context is, in fact, unique; e.g., if, in the example above, CULTURE-2 were the only blood culture in the consult then its translation would be simple 'the blood culture'. Most context types are 'non-unique' and will not have a UNIQUE property. The property is not necessary even on unique context; it exists simply to reduce excess verbiage where possible.

If your system has no context tree, you need only fill in the properties listed above for the main (root) context type. If you have a non-trivial context tree, however, it is also necessary to supply the following properties for non-root types: PROMPT1ST (or PROMPTEVER), PROMPT2ND, ASSOCWITH, and OFFSPRING.

PROMPTEVER - the 'prompt' that will be printed when the first context of this type is created. Only context types that will ALWAYS be created have PROMPTEVERs; if you have to ask whether there are any contexts of this type, then there should be a PROMPT1ST instead. E.g., in MYCIN, there is always at least one KNOWNORG under every POSCUL (by definition a positive culture is one from which organisms grew), so KNOWNORG has the PROMPTEVER (The first organism isolated from * will be referred to as:). [In PROMPTEVER, PROMPT1ST, and PROMTP2ND, the * will be filled in by the parent context.]

PROMPT1ST - the prompt asking whether contexts of this type exist. Unlike PROMPTEVER, this is a real question and requires an answer. E.g., the PROMPT1ST of CURTHER is (Is * currently receiving therapy with any anitmicrobial agent?).

PROMPT2ND - the prompt asking whether additional contexts of this type exist (to be used after at least one context of this type has been created). Omission of this property indicates that there is never more than one instance of the context under the parent context. E.g., the PROMPT2ND of KNOWNORG is (Were any other organisms isolated from * ?).

ASSOCWITH - a list of ancestor context types, showing this context type's location in the context tree. E.g. the ASSOCWITH of KNOWNORG in MYCIN is (POSCUL PERSON) and the the ASSOCWITH of POSCUL is (PERSON). This means that a POSCUL context is directly below the patient context, and that a KNOWNORG context is directly below a POSCUL.

OFFSPRING - a list of descendent context types, indicating which types that can hang directly below a context of this type in the context tree.

Context types may have other optional properties. If the context type is ever to appear in a rule, it must have a TRANS for translation (see description of a TRANS property in PARAMETERS.DOC). The * in the TRANS property of a context type is filled in by a translation of the tree root (main context). If you plan to use the SUMMARY option, the context type will need a CNTXTSUMMARY property as described in FEATURES.SUMMARY. If parmaters of the context type are to be gathered in a block using the TAB option for tabular input, it will need the TABPARMS, TABHEAD, TERSEHEAD, TABSTOPS, and LEGALTERM properties as described in FEATURES.TABULAR-INPUT.

Properties of Parameters

Below is a list of the properties that a parameter can have. All parameters need a TRANS. If the value of the parameter is ever requested of the user, it needs a PROMPT and EXPECT, and if applicable, LABDATA. Numeric parameters should have a CHECK property, and possibly a DEFAULT.

TRANS - how to translate the parameter. The TRANS is list; if it contains the atom *, the latter will be filled with the translation of the context to which this parameter belongs (e.g. (the identity of *)). Special verbs, such as "is", "has" (all those on the list TRANSVERBS), as well as the word "not" should be present as lower-case literal atoms for correct translation of the negation when the parameter is used in rules.

PROMPT - how to ask for the parameter's value; no PROMPT means that it makes no sense to ask the user for the value. The PROMPT a list; when the question is asked, the * in the list is replaced by the translation of the context being asked about; for multivalued parameters which are not "ASKALL", the atom "(valu)" is replaced by the particular value being asked about.

EXPECT - the set of legal answers to questions asking about this parameter. A null EXPECT is implicitly (YES NO).

The most common form of the EXPECT property is a list of the values (atoms). If an element of the EXPECT list is itself a list rather than an atom, it will be a list of one element and that element is to be evaluated to produce a list of values. Usually the code to be evaluated will be the name of a list. This is useful when more than one parameter will have the same list of possible values. The code to be evaluated, however, may be arbitrary Lisp code which produces a list. This will be useful if the list of legal values depends on some previous answer; e.g., in MYCIN, valid answers for COLLECT (method of collecting a culture specimen) depends on SITE; the form evaluated may reference CNTXT - the object for which you are asking, and PARM - the parameter.

A few atomic EXPECTs are recognized:

ANY - no restriction of the value
NUMB - the value must be a number
POSNUMB - the value must be a positive number
DATE - the value is a date

LABDATA - To you find out the value of this parameter, first try asking the user. The original meaning was that the parameter was the result of a quantitative lab test; this has been generalized to be anything that the user is likely to know. If the user does not give a definite answer to the question, the system will use rules (if any exist) to deduce the value. For parameters that have no LABDATA property, the system first tries to conclude the value using rules, and only asks if no value was concluded (and a PROMPT exists).

DEFAULT - if a numeric-valued parameter, the default units. This allows the user to give the answer in a different unit, and the system will convert it to the default units. The rules assume that the value is given in the default units.

CHECK - A form to EVAL to make sure that the user's numeric response is 'reasonable'. The CKECK property has the form:

(CHECK VALU lower-bound upper-bound text confirm integer)

VALU will be bound to the user's numeric response to the question; you must supply the lower and upper bound. Text will be printed if VALU is not within the indicated range. Confirm can be T or NIL: if T, the user may confirm that the answer is correct: if NIL, an answer outside the range is always a mistake. Integer may be T or NIL; if T, the answer must be an integer.

MULTIVALUED - the parameter is multivalued. This means that it can have several different correct values at the same time. (E.g., ALLERGIC the patient may be allergic to more than one drug.) This is different form the normal case in which the parameter is assumed to have a single correct value, and different values that are concluded represent competing hypotheses as to the true value.

If the value of the MULTIVALUED property is T, a separate question will be asked for each value (e.g., 'Is the patient allergic to penicillin?'). If the value is the atom ASKALL, one question will be asked in which the user is expected to give all the values (e.g., 'Please list all the antibiotice to which the patient is allergic.').

The TRANS of a multivalued parameter is stated in the plural (e.g., (the drugs to which * is allergic)). This phrasing is necessary for proper translation throughout the system.

PROPERNOUN - if the value should be capitalized in translation (e.g., NAME), then the parameter should have PROPERNOUN property T.

LEGALVALS - Always the list of all legal values for this parm, but is omitted if redundant (which it is for most parameters). All multivalued parms have a LEGALVALS property. In addition those parameters with EXPECTs which are pieces of code also have one. When a parameter has no LEGALVALS, the legal values are assumed to be specified by the parameter's EXPECT property. A parameter with no EXPECT or LEGALVALS will be treated as a yes/no parameter; this affects its translation in many parts of the system. The LEGALVALS property may be of the same forms as an EXPECT property. Two atomic forms are recognized. The atom CNTXT indicates that this parameter takes other contexts as its value (e.g., in MYCIN, the TREATFOR property of the patient is the list of all the organisms in the context tree that should be treated). The atom TEXT means that the parameter takes arbitrary pieces or text as its value. This will probably be the case for some goal parameter - the text will be the system's final analysis or recommendatios.

CNTXTVAL - To be used when the LEGALVALS is the atom CNTXT. The value of this property is a list of PROP-VALs (context types) indicating that contexts of the specified type(s) can be values of this parameter. The value may also be a function of a context (?).

SPECIAL - indicates ambiguous answers to the PROMPT. Usually of form ((<ambiguous response> <request for clarification>) ...) May also be triples with 3rd element a default value in case user responds UNKNOWN.

XTRASPECIAL - indicates a response to a question that actually includes the values for more than one parameter; is usually a list of lists ((<response1> <parm1 value1> <parm2 value2> etc.) (<response2> etc.) meaning that the response given should be used to conclude the values for the parameters; may also be ((<response1> code) ...) meaning that the code should be executed when the response has been given; some entries are of the form (<code> <parm1 parm2>) meaning that if the code EVALs with the given response, then a new value will be indicated-- the new value is the value for parm1 and the user's response is the value for parm2 (e.g., yes/no parameters when an answer other than yes or no is given)

REPROMPT - more specific than original prompt, is printed out when the user enters "?" in response to the oiginal prompt.

APPENDIX I

DECAIDS Knowledge Acquisition Procedures[1]

The following procedures are provided as a quick reference to fill in a new knowledge base or modify an existing one. The system designer will be required to declare parameters, define rules, and to save (make a file called CHANGES) the declarations and definitions. The parameters declared may be context names, rule group names, or value parameter names. The EMCYIN structure prompts (requests for values from the designer), for the types of parameters mentioned above, will be summarized in this section and examples will be provided. A carriage return must be typed after each sample command. Entering the EMYCIN file is accomplished as decribed in Appendix C.

A. DECLARING PARAMETERS

1. To declare parameters the designer enters the following command after the EMYCIN prompt of "_"

GETPARMS

2. The system will respond with:

PARAMETER NAME:

3. If the system designer then responds with the name of a new parameter, the system will commence prompting for parameter property values.

[1]From the combined research of Roland, Buscemi and Masica.

4. The first prompt for a property value will be:

    PROPGROUP:

5. A response to PROPGROUP of

    a. ALLNAMES: signals the system that the parameter is to be a rulegroup name

    b. PROP-VAL signals that the parameter is to be a context name, and

    c. PROP-(name) signals that the parameter is to be a value parameter in the parameter grouping of (name) which is of the designer's choosing.

6. RULE GROUP DECLARATIONS

    a. If the parameter is to be a rule group, then the next property prompt will be

        CONTEXT?

    b. The designer should respond with the context(s) names to which the rules of the named rule group will apply, i.e.:

        ORGANIZATION

    c. The next property prompt will be:

        SVAL:

    d. The designer shall respond with the appropriate context name, i.e.:

        ORGANIZATION

    e. The following prompt will be for:

        CTRANS:

f. The appropriate context name is the correct designer response, i.e.:

    ORGANIZATION

g. The next prompt will be for:

    PROPTYPE:

h. Here, the designer should respond with:

    PROP-ALLNAMES

   The system will return with a prompt for:

    SUBPROPERTY:

   A carriage return after "SUBPROPERTY" will return a system response of:

    PARAMETER NAME:

   A carriage return after "PARAMETER NAME" will take the user out of the GETPARMS subprogram and return a:

    DONE

7. CONTEXT DECLARATIONS

a. If the response to PROPGROUP is PROP-VAL, then the first prompt for a context parameter will be:

    TRANS:

b. The designer response to "TRANS:" is the designer's literal interpretation of his intent for this context name, i.e.:

    (the organization)

c. The next property prompt is:

MAINPROPS:

d. The designer response may be a carriage return if no MAINPROPS are to be used or a list of parameter names, i.e.:

(PROBTYPE TASK STRUCTURE TECHNOLOGY)

e. The context parameter's next property prompt will be:

PROPTYPE:

f. The designer should respond to PROPTYPE with the value parameter group(s) names to which this context will apply, i.e.:

PROP-ORG

g. The next property prompt will be:

TYPE:

h. The correct designer response to "TYPE:" is the appropriate context name, i.e.:

ORGANIZATION

i. The system will next prompt for a response to:

RULETYPES:

j. Here, the proper response is the rule group(s) names to which the context will apply, i.e.:

(ORGRULES)

k. The final property prompt seen in context declarations in DECAIDS is:

GOALS:

l. The designer should respond with those goal-parameters for the current context, i.e.:

    (DECAIDS FORMAL UNKSTRUC)

m. After prompting for the standard property values listed above, the system will request:

    SUBPROPERTY:

n. If the designer has a need to use additional property values, such as LABDATA, then he should respond to "SUBPROPERTY:" with the name of that property which he should use, i.e.:

    LABDATA

o. The system will then prompt the designer to provide a value for the subproperty just defined, i.e.,:

    LABDATA:

p. A proper response to "LABDATA:" is:

    T

q. When the designer has completed declaring parameters, a carriage return should be entered to the systems request for another subproperty definition.

r. The system will next return with:

    PARAMETER NAME:

A carriage return reponse here will cause a system response of:

    DONE

and return the designer to the EMYCIN.EXE file with its "_" prompt.

8. SAVING FILES

   a. The above work is saved in a CHANGES file with the following command:

      MF CHANGES

   b. The EMYCIN file will return the now current edition number of the CHANGES file.

9. CHANGING A PROPERTY VALUE

   a. Changes to a property value are made by typing the property name while still in the GETPARMS subprogram, i.e.:

      PARAMETER NAME: STRESS

      SUBPROPERTY: TRANS

   b. The system will return that subproperty to the designer expecting a new value to be entered, i.e.,:

      TRANS:

   c. The designer should enter a new value and a carriage return, i.e.:

      (THE NEW ORGANIZATION) carriage return

   d. The system will challenge with

      [NEW VALUE]

   e. On the same line as "[NEW VALUE]" the designer must respond with:

      Y, for "YES" or N, for "NO"

f. The system will then continue prompting with:

SUBPROPERTY:

B. DEFINING RULES

1. Rules are defined by initiating a call to the GETRULES subprogram with:

GETRULES]

2. The system will respond with:

RULE#, NEW or SUBJECT FOR NEW RULE:

3. To enter a new rule, the designer must respond with:

NEW

To edit an old rule, the designer must respond with the desired rule number to be edited.

4. After "NEW" is typed by the designer, the system will respond with:

ANTECEDENT RULE?

5. In most cases the rule will not be an antecedent rule and the correct response is simply:

N

6. The system next sends:

RULE (number)
PREMISE:

7. For a new rule, the designer should first define a rule premise and should respond to 6 above with his premise statement, in the INTERLISP syntax, i.e.

($AND (SAME CNTXT STRESS LOW))

8. The system's response will be either:

    a. an error message for syntax or undeclared parameter,

    or

    b. RULE (number)
    ACTION:

9. In response to the system's request for the ACTION statement, the designer should enter the rule's appropriate action statement, i.e.:

    (CONCLUDE CNTXT SIZE LARGE TALLY 900)

The "TALLY 900" is the designer's certainty factor entry.

10. The system may again respond with an error message or return:

    SUBJECT OF RULE (number) IS (rule group name)

    [CONFIRM]

11. If (rule group) is the correct name to which the rule belongs, then enter

    Y

immediately after [CONFIRM], i.e.:

    [CONFIRM] Y

12. If in response to "RULE#, NEW or SUBJECT FOR NEW RULE:," the designer enters a rule number, the system will return:

    TRANSLATE, DELETE, NO CHANGE, or NAME of PROP TO MODIFY:

13. The designer may now specify the premise or action statement if he chooses to edit either, i.e.:

TRANSLATE, DELETE, NO CHANGE, or NAME of PROP to MODIFY: PREMISE

14. The system will respond with the current premise value and on the next line return:

PREMISE:

awaiting the new value.

15. After the new value has been entered, the system will challenge with:

[NEW VALUE]:

A "Y" for "yes" for "N" for "no" immediately after [NEW VALUE] is the correct response.

16. A carriage return after RULE#, NEW or...will cause the system to return:

DONE

17. Rules may now be saved with:

MF CHANGES

18. Debugging of error messages may be facilitated by reference to the XEROX INTERLISP Manual and via communications with the AI personnel at Stanford University. ARPANET address:

SCOTT@@@SUMEX-AIM

Carlisle Scott is a programmer with the AI group at Stanford University who has provided a great deal of assistance in learning the EMYCIN system.

C. PRINTING PARAMETERS AND RULES

1. The parameters list is printed out with the following command:

   PRINTPARMS (NIL T 72 T)

2. The rules may be listed with the following command:

   (PRINTRULES rulegroup name 'B)

D. LEAVING THE DECAIDS FILE

1. Entering a CONTROL-C with no carriage return will return the system designer or consultation user to the TOPS-20 operating system.

2. The command:

   LOGO

will log the system user off of the computer at ISIE and off of the ARPANET TIP.

3. The system will terminate with:

   KILLED JOB #, USER DECAIDS, ACCOUNT NPF-OTHER-STUDENTS, TTY 135, at (datetime), USED (time) CLOSED.

4. The session is now complete.

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Dr. G. Poock 1
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Naval Postgraduate School
Monterey, CA 93940

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Command, Control & Communications Group
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Naval Postgraduate School
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Department of Administrative Science
Code 54Cf
Naval Postgraduate School
Monterey, CA 93940

Dr. C. Eoyang 1
Department of Administrative Science
54Eg
Naval Postgraduate School
Monterey, CA 93940

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Bekins Transportation & Warehousing Group 1
777 Flower St.
Glendale, CA 91201

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Bank of America
#3680, Floor 20
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San Francisco, CA 94119

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VP Data Services
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Westinghouse Electric Corp.
Stanwix St. and Ft. Pitt Blvd.
Pittsburgh, PA 15222

Mr. H. Downing, Jr. 1
V.P., Business Systems
USAA Bldg.
9800 Fredericksburgh Rd.
San Antonio, TX 78288

Mr. R. Erb 1
Electronic Data Systems Corp.
2150 Garden Road
Monterey, CA 93940

Prof. W. R. King 1
Graduate School of Business
University of Pittsburgh
Pittsburgh, PA 15261

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